Geology of the Jackson Area Mississippi

GEOLOGICAL SURVEY BULLETIN 986

Geology of the Jackson Area Mississippi

By WATSON H. MONROE

GEOLOGICAL SURVEY BULLETIN 986

Stratigraphic and structural study of the area surrounding the Jackson gas field

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1954

UNITED STATES DEPARTMENT OF THE INTERIOR

Douglas McKay, *Secretary*

GEOLOGICAL SURVEY

W. E. Wrather, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price $1.75 (paper cover)

CONTENTS

ILLUSTRATIONS

[All plates in pocket]

GEOLOGY OF THE JACKSON AREA, MISSISSIPPI

By Watson H. Monroe

ABSTRACT

The Jackson area, comprising about 660 square miles, is in west-central Mississippi in Hinds, Madison, Rankin, and Scott Counties. It is in the eastern part of the Gulf Coastal Plain near the southern extremity of the Mississippi embayment. The western side of the Jackson area as mapped is about 25 miles east of the axis of the major syncline that marks the deepest part of the embayment. Physiographically the area is within the two provinces named by Lowe the Jackson Prairie Belt and the "Long Leaf Pine Hills." The lowest altitude in the area, on the Pearl River, is about 215 feet above sea level. The highest altitude is about 520 feet at Ware Hill, 2½ miles northwest of Pelahatchie, and at Brandon; but south of Morton, Scott County, just east of the area, a hill-crest is 631 feet above sea level.

The rocks at the surface include formations ranging in age from Eocene to Recent. The oldest rocks exposed belong to the Cockfield formation at the top of the Claiborne group. These consist of sand, clay, and lignite. Overlying the Claiborne group is the Jackson group consisting of 450 feet of calcareous sand and clay (the Moodys Branch formation and the Yazoo clay). Above the Jackson group is the Forest Hill sand, about 100 feet thick. The Forest Hill is overlain by the Vicksburg group consisting of the Mint Spring marl member of the Marianna limestone, a highly fossiliferous sandy marl about 10 feet thick, and the Byram formation. The Byram contains three members, the Glendon limestone member about 24 to 30 feet thick, a middle marl member about 30 feet thick, and the Bucatunna clay member consisting of about 60 to 65 feet of massive clay and cross-bedded sand. Overlying the Vicksburg group is the Catahoula sandstone, a formation of sand, clay, and sandstone.

Resting unconformably on the older formations are many kinds of surficial deposits, which include high-level gravel deposits, river-terrace deposits, alluvium, and loess or brown loam.

Deep oil test wells have been drilled into rocks as old as Jurassic(?), but most wells near Jackson have been drilled for gas and drilling has stopped at the gas-producing bed at the top of a limestone of Cretaceous age, known as the "gas rock." A few wells near Jackson have been drilled through the base of the gas rock to enter beds of sandstone and shale referred to the Cotton Valley (?) formation of Jurassic age. Interbedded with and cutting across the bedding of this formation are many bodies of igneous rock including varieties of nepheline syenite, lamprophyre, aplite, and sanidine-calcite rock. A few wells have been drilled through the gas rock into black clay, presumably a lake deposit, underlain by volcanic ash. Wells drilled several miles away from Jackson have entered the normal sequence of Upper Cretaceous rocks of the Selma group, the Eutaw formation, and the Tuscaloosa group.

The gas rock consists of 280(?) to 500 feet of very pure calcium carbonate. Overlying it is the normal sequence of Tertiary rocks, which, however, are thinner near Jackson than elsewhere within the area. The Midway group consists of a thin bed of limestone (the Clayton formation) overlain by black clay (the Porters Creek clay) which is about 100 feet thick, near Jackson, but as thick as 800 feet south of Jackson. The Midway group is overlain by sand, clay, and lignite of the Wilcox formation, 1,200 feet thick near Jackson and 2,500 feet thick south of Jackson. The Wilcox formation is overlain by the Claiborne group which consists of 1,100 feet or more of soft glauconitic limestone or marl, sand, clay, and lignite.

The most prominent structural feature in the area is the Jackson anticline, which is about 25 miles long from southwest to northeast and 23 miles wide from northwest to southeast. The closure of this anticline toward the northeast is between 150 and 350 feet. The closure increases downward, and a closure of more than 1,000 feet is probable at the depth of the top of the Cretaceous. Faulting is suggested in a few exposures, but definite evidence has not been seen.

Gas was discovered on the Jackson anticline in 1930 in the top of the gas rock of the Cretaceous age, and by 1941, 152 gas wells and 44 dry holes had been drilled on the crest of the anticline. The gas was produced only at those places where the cap rock was reached at depths less than about 2,220 feet below sea level. The number of producing wells increased from 5 in 1930 to 114 in 1935, but since then has declined, and in 1950, only 12 wells were still producing. The ultimate production of the field will be about 120,000 million cubic feet, for as the gas is withdrawn salt water advances from the sides and from below and fills the permeable rock formerly containing the gas.

About 25,000 barrels of heavy (13.6° API gravity) oil was produced from short-lived wells on the south side of the gas field.

Minor mineral resources in the area include sand and gravel, brick clay, building stone and riprap, and limestone suitable for the manufacture of portland cement.

INTRODUCTION

HISTORY OF THIS INVESTIGATION

Shortly after the discovery of natural gas at Jackson, Miss., in 1930 the Geological Survey decided to extend the work begun by Oliver B. Hopkins in 1915 by making a survey of the geology and mineral resources of the Jackson quadrangle. After 2 months field work the writer prepared a preliminary report on the Jackson gas field, which was published in 1932 (Monroe, 1932b). In 1931 the writer, assisted by M. A. Pentz, extended the mapping from the Jackson quadrangle into the adjoining Florence and Pelahatchie quadrangles. It was thought desirable to redraft the topographic map of the Jackson quadrangle, because of many inaccuracies, and this was done largely by primitive photogrammetric methods using aerial photographs taken by the Army Air Corps. In 1936 the geology of the eastern third of the Raymond quadrangle was mapped, but in less detail than other parts. A report on the State of Mississippi's deep test well (Fee No. 2), and of the history of the gas field was published in 1937 (Monroe and Toler) with H. N. Toler as joint author. In the spring of 1939 the writer, assisted by G. R. Pierce, made plane-table surveys for structural information.

Since 1939 much deep drilling has been done in the Jackson area. The writer has not had opportunity to study the samples from these new wells, so the present report discusses principally the surface features. The earlier publications have discussed briefly the subsurface geology of the area, and little is added to these descriptions. Samples from several of the early deep wells, no longer available for examination, are described in the hope that these descriptions will be of comparative value to present workers.

The manuscript of this report was written by the author soon after the completion of the field investigation but its publication has been delayed by emergency conditions arising from World War II.

ACKNOWLEDGMENTS

Throughout this work the writer has been helped by many individuals in the oil and gas industry, by local residents, and by various geologists of the Geological Survey. Especial recognition should be made of the services of his field assistants, M. A. Pentz and G. R. Pierce; of his supervisors, C. W. Cooke, L. W. Stephenson, and G. R. Mansfield, who visited the field parties and offered valuable corrections and advice; C. S. Ross, who studied the petrology of clays and igneous rocks; P. G. Nutting, who studied the bleaching qualities of clay samples; C. F. Park, Jr., who made a special study of the igneous rocks from several of the deep wells and whose contribution is included in this report; H. D. Miser, who advised on the oil and gas problems of the area and who always offered encouragement in his comments; and F. S. MacNeil, who helped study the stratigraphy of the Oligocene deposits. The State Oil and Gas Supervisors, H. N. Toler and H. M. Morse, were most helpful in giving data about the drilling and production of the gas field, and Mr. Toler has accompanied the writer in the field many times to help solve disputed points of the geology. No attempt will be made to acknowledge individually the help given by employees of the oil and gas companies operating in the area, for aid has been received from nearly all. C. A. Carlson of the U. S. Engineer Office, Mobile, Ala., very kindly furnished a boat for a trip down the Pearl River in 1939; during the trip the thickness of the Byram was measured. The descriptions of cores include quotations from L. G. Henbest, Charles Milton, H. D. Miser, C. F. Park, Jr., C. S. Ross, L. W. Stephenson, and Julia Gardner of the Geological Survey, and R. D. Norton of the Texas company.

LOCATION AND GENERAL RELATIONS

The area described in this report is in west-central Mississippi in Hinds, Madison, Rankin, and Scott Counties. Jackson, the capital of the State, is in the western part of the area. As mapped the area includes the Jackson quadrangle (pl. 1), the eastern third of the Raymond quadrangle (pl. 2), the northern third of the Florence quadrangle (pl. 3), and the Pelahatchie quadrangle (pl. 4), comprising a total area of about 660 square miles (see fig. 1).

The area is in the eastern part of the Gulf Coastal Plain near the southern extremity of the Mississippi embayment. The western side of the area is about 25 miles east of the major syncline that marks the deepest part of the embayment.

Railroads belonging to the Illinois Central and Gulf, Mobile, and Ohio systems radiate from Jackson to Memphis and Jackson, Tenn., Meridian, Gulfport, New Orleans, Natchez, and Vicksburg. Jackson is also the junction point of several airlines.

Three paved national highways cross the area—U. S. 80 between Meridian and Vicksburg, U. S. 49 between the Delta counties and Gulfport, and U. S. 51 between Memphis and New Orleans. In addition, paved and graveled State highways and county roads serve the area adequately.

Jackson is a center of pipelines for natural gas in Mississippi. The main line of the United Gas System from Louisiana to Mobile, Ala., and Pensacola, Fla., crosses the area just east of the city, and during the productive life of the field was connected to most of the wells by feeder lines. Another line of the United carried gas from Jackson south to McComb, Miss., and Bogalusa, La. A pipeline of the Mississippi Power & Light Co. extended from Jackson to Clinton. The line of the Willmut Gas & Oil Co. connects Jackson and Hattiesburg, Miss. A municipal line carried gas to Canton from wells owned by the city of Canton.

Jackson is the largest city in the area, having a population in 1950 of 98,271 (1950 figure of Census Bureau). The rest of the area contains smaller towns, which provide local trading centers. The largest of these are Clinton, Brandon, and Pelahatchie, all on the main east-west highway U. S. 80. Jackson contains several schools of higher education including Millsaps College, Belhaven College, and Jackson College (colored).

PREVIOUS WORK IN THE JACKSON AREA

For nearly a century the fossiliferous deposits of the Jackson area have been a source of interest to paleontologists. Sir Charles Lyell on March 19 and 20, 1856, visited Jackson and collected shells from

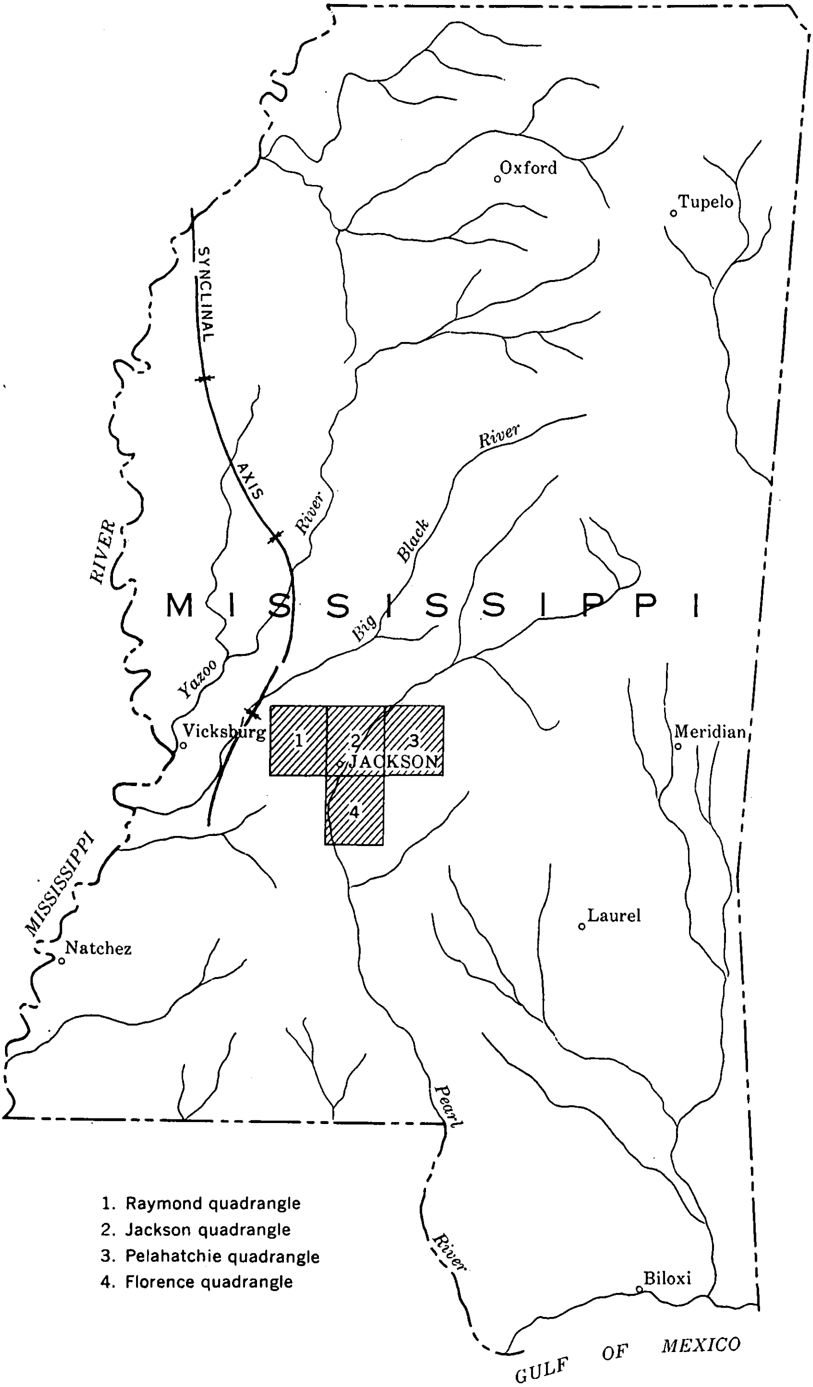

FIGURE 1.—Index map of Mississippi showing location of the Jackson area and the axis of the Mississippi embayment syncline.

the Moodys Branch formation. Conrad (1847, pp. 280–299) described fossils collected at Vicksburg, mostly from the Byram formation and proposed the name Vicksburg group. In 1855 he (Conrad, 1855, pp. 257–263) described species from the basal Jackson (Moodys Branch formation) and proposed the name Jackson group.

Soon after its organization the Mississippi Geological Survey issued progress reports by Wailes (1854) and by Harper (1857) culminating in the classic report by Hilgard (1860).

Hilgard was the first geologist to make a systematic study of the outcropping geologic formations in the Jackson area. He described the major geologic divisions recognized in the present report, and recognized most of the minor divisions giving, with a few minor errors, their correct stratigraphic succession. He correctly identified the lignitic strata exposed on Moodys Branch with those underlying the Jackson group north of Canton, and postulated a "local upheaval" to account for this repetition of section. His report is still the standard reference for geologists working in many parts of Mississippi.

In 1886 Langdon (1886, pp. 202–209) published the results of studies on Pearl River between Jackson and Byram.

In 1903, R. H. Henry, World's Fair commissioner of Mississippi, requested the United States Geological Survey to collect specimens of Mississippi's mineral resources for exhibition at St. Louis. In connection with this work Crider (1906) assembled data for a new report on the geology of Mississippi, in which the geology of the Jackson area is reviewed and additional data on the magnitude of the Jackson anticline are given.

In 1907 Crider (pp. 59–67) described the Vicksburg limestone and included numerous analyses to show that the purer part (Glendon limestone member of the Byram formation) is suitable for the manufacture of portland cement. In the same year Logan (1907, pp. 191–192, 227–231) described brick clays from the Jackson area.

Lowe (1915) published a summary of the geology of Mississippi, which marked an advance beyond the earlier work by subdividing the State into physiographic or topographic districts and by dividing many of the earlier groups into formations. Lowe applied the Louisiana name Cockfield to the lignitic beds at the top of the Claiborne group and divided the Jackson group into Yazoo clay marl, the Moodys Branch green marls, and the Madison sands. Later editions of this summary containing minor corrections were published in 1919 and 1925.

In 1916 Hopkins (pl. VIII) published a structure contour map of the Jackson-Vicksburg area and recommended drilling for oil and gas at Jackson. Although Lowe (1915, p. 127) had suggested that the Jackson anticline would prove a favorable place to drill for oil, it was not until the publication of Hopkins' report that drilling was begun by companies financially able to drill adequately deep test wells.

After two unsuccessful holes were drilled north of Jackson, Lowe (1919b, pp. 24–28), was able to show that these wells had penetrated the base of the Jackson group at depths much lower than the outcrops in the city of Jackson and that they were thus drilled too far down on the flanks of the dome as it is expressed by the rocks at the surface. This report was followed in 1923 by a supplement (Lowe, 1923, pp. 16–190).

In 1916 Matson (1916a, pp. 167–192, pls. 32–43; 1916b, pp. 209–226, pls. 48–54) named and described the Citronelle formation and the Catahoula sandstone and Berry (1916a, pp. 193–208; 1916b, pp. 227–251, pls. 55–60) in the same papers described their flora.

In 1918 Shaw (pp. 125–163) reviewed the history of the Lafayette formation problem. He described the materials included in the formation, and examined critically the physiography of the upland regions of Mississippi. He came to the conclusion that much of the so-called Lafayette formation consists of weathered residuum, some is colluvium, some consists of river terrace gravels, and some can be included in the Citronelle formation. He suggested that the peneplain at the base of the highest-level gravel terrace of the Citronelle might be the southern extension of the Highland Rim peneplain of central Tennessee. He also suggested that the Big Black River above Canton might once have been a tributary of the Pearl River.

Cooke in 1918 (pp. 186–198) reviewed the stratigraphy of the Jackson and Vicksburg groups. Treating the Jackson as a formation he divided it into the Moodys calcareous marl member and the Yazoo clay member. He suggested the name Forest Hill sand to replace the preoccupied name Madison sands of Lowe, and he placed the formation at the base of the Vicksburg group. He defined the Marianna limestone and placed in it, as members, the Glendon limestone and the Mint Spring marl, which he named in this paper. He named the Byram calcareous marl and included in it the beds now assigned to the Chickasawhay limestine. In 1923 (Cooke (pp. 1–9) raised the Glendon to the rank of a formation and defined more rigidly the units of the Vicksburg.

Because of the considerable amount of deep drilling that had been done in the State up to 1927 Grim (1928) was able to make an interesting study of the subsurface geology. He concluded that the Jackson anticline was the result of crustal movement, probably faulting. His generalized structure contour map does not show the axis of the syncline of the Mississippi embayment.

In 1932 Monroe (1932b, pp. 1–17) briefly described the geology of the Jackson gas field down to and including the producing chalk bed (gas rock). In 1933 this paper was supplemented by one (Monroe, 1933) describing the rocks below the chalk. In this later paper, however, the deepest rocks found in the field were erroneously called Carboniferous. Later studies have suggested that they should rather be considered Jurassic or possibly Lower Cretaceous. Subsequent history of the Jackson gas field and descriptions of the rocks from the deepest well drilled in the area up to 1937 were included in a bulletin by Monroe and Toler (1937).

An excellent summary of the geology and gas production of the Jackson field by Munroe (pp. 881–896) was published in 1935 as one of 38 papers on the geology of natural gas. Munroe's estimate of the gas reserves in the field has proved to be remarkably correct.

In 1935 Bay (p. 42) described possible bentonitic clay from the Yazoo clay in Hinds County. Mechanical analyses and petrographic studies of samples of the Moodys Branch formation, the Yazoo clay, and the Forest Hill sand were published by Grim (pp. 216–224) in 1936. He did not recognize the disconformities at the base of the Moodys Branch or at the top of the Forest Hill, and he included the Forest Hill sand in the Jackson group.

In 1941, a study group of the Mississippi Geological Society, of which Arthur Wedel (1941) and A. A. Holston were chairmen, published the results of an intensive study of the subsurface stratigraphy of the Mesozoic rocks in Mississippi based on well samples and electrical logs.

Numerous papers have also been published describing fossils obtained from the formations in the area.

PHYSICAL GEOGRAPHY

DRAINAGE

Most of the Jackson area lies within the drainage basin of the Pearl River, but the northwestern corner of the Jackson quadrangle and the north half of the mapped part of the Raymond quadrangle (T. 6 N., R. 1 W.; Ts. 7 and 8 N., Rs. 1 W. and 1 E.) are drained by tributaries of the Big Black River. Except for the rather swampy alluvial plains of the larger streams the area is well drained. Bogue Chitto Creek and its main tributary Limekiln Creek drain most of the area within the Big Black drainage basin except along the northern edge of the Jackson quadrangle, where Bear Creek drains the area. The Big Black drainage is rapidly cutting back into the Pearl drainage basin because the gradient of the headwater streams is much steeper than that of the Pearl River. The divide between the two systems is, in fact, only a mile northwest of the Pearl River in sec. 32, T. 8 N., R. 3 E.

No large tributary streams enter the Pearl River from the west, but several with long courses enter from the east. The largest of these are Steen Creek, which drains the central part of the Florence quadrangle; Richland Creek, which drains the northern part of the Florence quadrangle and the southeastern part of the Jackson quadrangle and heads in the southwestern part of the Pelahatchie quadrangle; and Pelahatchie Creek, which drains most of the Pelahatchie quadrangle and heads in Scott County near Morton, east of the mapped area.

The gradients of all these streams are very gentle, most of them less than 10 feet to the mile except in the headwater branches. The gradient of the Pearl River is about a foot to the mile, the flood plain itself sloping at a rate of less than 2 feet to the mile.

PHYSIOGRAPHIC DIVISIONS

Lowe (1919a, pp. 29–35) has divided the Coastal Plain of Mississippi into 10 physiographic regions, two of which include the Jackson area. The northern part of the area is in the Jackson Prairie belt and the southern part in the Long Leaf Pine Hills, now known as the Southern Pine Hills.

JACKSON PRAIRIE BELT

The Jackson Prairie belt is a strip of very gently rolling country characterized by treeless patches ranging in size from a few acres to several square miles. The gentle topography is well shown in the northern half of the Pelahatchie quadrangle where slopes as gentle as 10 feet to the mile, and in places even gentler, are common. The prevailing soil is calcareous clay, greenish yellow to black, and very plastic, classed by the Bureau of Soils (U. S. Bureau of Chemistry and Soils, 1926) with the Houston, Oktibbeha, and Montrose series. This soil is the weathered product of the Yazoo clay. In the western part of the area these clay soils are concealed by soil known as the Grenada silt loam derived from highly weathered wind-blown loess.

Most of the streams of the Jackson Prairie belt flow in wide, flat bottoms which merge nearly imperceptibly into the bordering uplands except near the Pearl River where the valleys have somewhat steeper sides. In much of the region, indeed, the topography has reached such a late stage of dissection that it may be said to be approaching old age.

SOUTHERN PINE HILLS

The Jackson Prairie belt merges toward the south into a region characterized by much more rugged topography—the Southern Pine Hills. The topography of these hills is much more youthful than that of the prairie belt, and may be said to be in early and middle maturity, rather than the late maturity of the prairie belt. Hillsides are steep and the crests of the hills range from flat to rounded. As in the prairie belt the streams flow in wide, flat flood plains that are sharply marked by the steep slopes of the hills.

The northern edge of the province is the abrupt scarp of the Forest Hill cuesta, which is characterized by a steep slope near the outcrop of the contact of the Yazoo clay and Forest Hill sand and by a more gentle back slope over the outcropping edges of the Forest Hill sand and limestones of the Vicksburg group. The cuesta is not so well developed as others in the Coastal Plain, for it has been modified by the terrace-forming processes of the larger streams, particularly the Pearl River, and by the great deposits of gravel, which underlie high-level plains.

Much of the southern part of the Southern Pine Hills in Mississippi is covered by gravel deposits, considered a part of the Citronelle formation, that form extensive, nearly flat plains. The highest and most extensive of these was named the Brookhaven plain by Matson (1916, pp. 180–181). The Brookhaven plain does not extend as far north as the Jackson area, but outliers of the gravels that underlie it are present in the Morton quadrangle east of the mapped area and in the Florence quadrangle just south of the mapped area. The outliers in the Morton quadrangle indicate that the surface of the plain, if still present, would have an altitude slightly greater than 630 feet in that area. The outliers in the southern part of the Florence quadrangle appear to retain a part of the original surface. The altitude of the plain decreases toward the southwest from about 540 feet near Star to about 500 feet near Pearl, Simpson County. Outliers suggest that the gravel deposit, and probably the plain, was once present over most of the Jackson area.

Remnants of a lower plain underlain by another gravel deposit are preserved on high hills west of the outliers of the Brookhaven plain. This plain, which was formed as a flood plain of the Pearl River, or some larger river, may be reconstructed from remnants on the crest of Ware Hill near Pelahatchie, from the remnant at Brandon, and from the sand-capped ridge between Fannin and Goshen Springs (Pelahatchie quadrangle), all of which have altitudes of about 500 feet. Other remnants lie on the divide between Steen and Richland Creeks in the northern part of the Florence quadrangle, where the altitude of the plain drops from about 450 feet at Monterey to about 400 feet, 3 miles east of Byram. Still others north of Forest Hill School in the Raymond quadrangle form gravel capped hills whose tops are about 480 feet above sea level. These facts indicate that the plain as reconstructed, generally slopes toward the south, and possibly toward Pearl River. These remnants are shown on the geologic maps (pls. 1–4) as high-level terrace deposits.

RIVER TERRACES

At least three river terraces border the valley of Pearl River and its larger tributaries. Two are separately mapped on the geologic maps (pls. 1 and 3) and one is included with the alluvium. The two higher terraces can be mapped in considerable detail. The highest maintains a rather constant altitude of about 380 feet from the northern edge of the Jackson quadrangle to the hills just north of Byram in the Florence quadrangle. It has not been recognized east of the Pearl River, but is extensively developed on the west side of the river. The middle terrace deposit appears to be present on both sides of the river valley at altitudes of about 300 to 320 feet, but is more conspicuously developed on the east side of the valley. The lowest terrace deposit is mapped with the alluvium. It is marked by an inconspicuous slope from the main alluvial plain of the Pearl River, Bogue Chitto Creek, and Pelahatchie Creek, and rises only about 5 feet above the alluvial plain.

FLOOD PLAINS

All the streams of the area are bordered by flood plains, the widest being that of the Pearl River, which, including the lowest river terrace, averages 3 miles in width. These plains are very flat and many contain depressions, some swampy, that represent abandoned channels of the streams. The flood plains of the Pearl River and of a few of the larger creeks have low ridges or natural levees near the present channel. These natural levees are formed during floods at places where the muddy streams drop sediment when their velocity is checked upon leaving their channels to flow through the wooded swamp land nearby. The natural levee on the Pearl is the largest in the area and is as much as 5 feet higher than the land away from the river. The flood plains of Bogue Chitto, Pelahatchie, and Richland Creeks have an average width of about 2 miles, and other streams have narrower plains; some small streams have flood plains only a few hundred feet wide.

RECENT DRAINAGE CHANGES

The Big Black River drainage is rapidly eroding back into the Pearl drainage basin, especially in the northwestern part of the Jackson area. Much of this erosion has taken place since deposition of the brown loam or loess. Small remnants of loess-covered valleys of streams that once flowed to the Pearl have been diverted to the Big Black by this rapid erosion. The best example of this recent stream piracy is in the northern half of sec. 16, T. 7 N., R. 1 E., where water starts to run south toward Whiteoak Creek, but is diverted by a gully and then flows east, thence north to a branch of Limekiln Creek, thence west to Bogue Chitto Creek, and finally northwest to the Big Black River. The topography in the SW¼ sec. 16 and in the adjoining sections is unusual for the Coastal Plain in that the small headwater branches flow west and north and are thus normal to each other. As some of these are coincident with section and quarter-section lines the writer has often wondered whether their erosion may not have begun when the land was surveyed in 1821. The survey lines cut through the forest may have become animal trails which wore through the sod to the underlying, easily eroded Forest Hill sand. Runoff of rain water along these paths would soon have carved gullies, which may have become the present valleys.

The channel of the Pearl River was mapped in 1821 by the surveyors who divided the land into sections; it was next mapped between 1901 and 1906 when the Jackson and Florence quadrangles were surveyed by the Geological Survey, and it was again mapped in 1931 by the writer from aerial photographs. The maps of these three periods show the changes in the Pearl River. The course of the river is much the same today as it was in 1821 except at a few places where bends have been abandoned and converted into ox-bow lakes and later into sloughs by accretion of alluvium. The 1821 map shows a large bend in sec. 24, T. 7 N., R. 2 E., that is shown as an ox-bow lake on the 1905 map. Both the 1821 and 1905 maps show a bend in sec. 3, T. 6 N., R. 2 E., which had become cut off into an ox-bow lake before the map of 1931 was made. The map of 1931 shows a bend in secs. 17 and 20, T. 6 N., R. 2 E., which is in the process of being cut off, for water at that time was flowing both along the old channel and along the new, shorter course. Similarly the map of 1821 shows a bend in secs. 2 and 11, T. 5 N., R. 1 E. in the process of being cut off. The lake formed by this cut-off has so filled now, that the slough is not easily recognized on the photographs. The tendency of meandering streams like the Pearl River is to cut the outer banks of bends and thus form great sweeping bends with narrowing necks, which later are cut off to form ox-bow lakes. It was hoped from this study of the former course of the river to determine the rate at which cutting was taking place, but it was found that the 1821 map was not accurate enough for such precise work.

Capture of the Pearl River by the Big Black is possible within a few hundred years if not prevented by man, for the headwaters of Bear Creek in sec. 32, T. 8 N., R. 3 E., Madison County, are eroding into the divide between the two drainage basins and the altitude of the headwater stream bottoms of the Big Black in sec. 29 is lower than the bed of the Pearl River 2 miles to the south.

STRATIGRAPHY

GENERAL FEATURES

The rocks exposed at the surface and those below the surface in the Jackson area, so far as known, are of sedimentary origin excepting some sills and dikes and ejected igneous rock which were penetrated in a few of the deeper wells drilled near the crest of the Jackson anticline.

The oldest rocks thus far reached by drilling are believed by most geologists who have studied them to be at least in part of Cotton Valley (Jurassic) age. On the flanks of the anticline, wells have been drilled into rocks believed to be of Trinity, Tuscaloosa, and Eutaw age. Overlying and truncating the edges of these rocks is a thick bed of very pure limestone that appears to be of Navarro age. It may represent the Prairie Bluff chalk or the upper part of the Selma group exposed in northeastern Mississippi. This limestone is generally designated the "gas rock" (Wedel and others, 1941, pp. 2, 3).

Above the gas rock is a series of formations of Tertiary age composed of limestone, marl, clay, and sand. These represent the normal sequence of rocks in Mississippi, but some of the formations are thinner at Jackson than elsewhere in the State (see pl. 2).

CONCEALED ROCKS

Most wells in the Jackson area have been drilled only to the gas rock at the top of the Cretaceous, but a few on the crest of the Jackson dome have been drilled much deeper into older Mesozoic rocks—sandstone, shale, and igneous and pyroclastic rocks. In addition, some wells on the periphery of the dome have penetrated a normal sequence of Cretaceous sedimentary rocks.

The writer studied cores and cuttings of many of the wells drilled before 1940, but has not had opportunity to study the samples from wells drilled since then. As the samples from many of these early wells have been lost or destroyed, detailed descriptions of several are included in this paper.

After 1940 a few wells were drilled on the flanks of the dome in an effort to find oil accumulations at places where the Eutaw formation and, perhaps, formations of the Tuscaloosa group pinch out, but the writer has not seen samples from these wells. The descriptions of formations below, therefore, refer only to the early wells drilled near the crest of the dome. In 1941 a study group of the Mississippi Geological Society (Wedel and others, 1941) published a series of cross sections that show well-to-well correlations of flank wells and the reader is referred to this report for details. Description of cores and cuttings from the State of Mississippi's Fee No. 2 well have previously been published. (Monroe and Toler, 1937, pp. 27–52).

ROCKS OF POSSIBLE JURASSIC AGE

At least two wells in the Jackson area were drilled into rocks of possible Jurassic age. These are the Gulf Refining Co.'s Hamilton No. 1 well in sec. 4, T. 5 N., R. 2 E., Rankin County, and the State of Mississippi's Fee No. 2 well in sec. 25, T. 6 N., R. 1 E., Hinds County.

The Jurassic age of these rocks is not certainly determined, for no diagnostic fossils have been found in the cores or cuttings. The writer (Monroe, 1933, pp. 49–51) originally considered them Carboniferous because carbonized wood found in some of the cores from the Hamilton well suggests high-rank bituminous coal, because the fibers of these wood fragments are pitted in a manner common in Carboniferous woods but very rare in those of the Cretaceous, and because some of the sandstone resembles sandstone of Pottsville age exposed in northern Alabama. Subsequent comparison of cores from the State well with cores taken from wells known to be in the Cotton Valley formation (then thought to be of Trinity age) in Louisiana led Monroe and Toler (1937, pp. 23–32) to correlate these rocks with the Trinity formation. The only basis for the correlation is lithologic resemblance with rocks of Cotton Valley age in Louisiana and Arkansas.

The rocks here considered to be the Cotton Valley(?) formation consist predominantly of massive and thin-bedded micaceous clay and claystone and massive and thin-bedded red and white micaceous, somewhat calcareous very fine to medium-grained sandstone and siltstone, some containing widely scattered fine grains of glauconite. In many of the cores the bedding dips at angles as great as 30° from a plane normal to the sides of the core, but as these cores also show fine cross bedding it is possible that some of this strong dip may represent cross bedding rather than a true dip of the rocks. Other rocks present, in smaller quantities are gray and black clay and shale and dark-gray limestone.

Some of the sandstone from the Hamilton and State wells suggests contact metamorphism near bodies of igneous rock. Some of the grains in these cores are small euhedral crystals of quartz probably formed by secondary enlargement of the irregularly shaped quartz grains in the sandstone. In the State well some of the sandstone has been metamorphosed to quartzite. Many of the cores are cut by veins along which calcite, iron oxide, and pyrite have been introduced.

The thickness of the supposed Jurassic rocks is not known. The State and Hamilton wells were drilled directly from the gas rock into sandstone and shale that is indistinguishable from similar rock below and did not penetrate the base of the series. The State well was drilled to a total depth of 5,530 feet. From 2,843 feet, the base of the gas rock, to the bottom of the well there was little change in the lithologic character of the rocks except near the bodies of igneous rock. Thus, this well penetrated a total thickness of 2,687 feet of Cotton Valley(?) formation and intrusive igneous rocks. No other wells at Jackson have penetrated so great a thickness of these rocks and none have penetrated their base.

ROCKS OF CRETACEOUS AGE

In the area of the Jackson gas field the rocks of Cretaceous age include a very pure limestone of probable Selma age, known informally as the gas rock, and some underlying sand, clay, and pyroclastic rocks that in a few wells underlie the gas rock and rest on either the Cotton Valley(?) formation or igneous rocks. In parts of the area away from the gas field, wells have penetrated a normal sequence of Lower and Upper Cretaceous rocks (Wedel and others).

PRE-SELMA CRETACEOUS ROCKS

The Louisiana Gas & Fuel Co.'s (now Union Producing Co.) Harris No. 1 well and the Jackson Oil & Gas Co.'s Taylor No. 1 well both in sec. 35, T. 6 N., R. 1 E., Hinds County, and the Gulf Refining Co.'s Rainey No. 1 well in sec. 13, T. 5 N., R. 1 E., Rankin County, penetrated the base of the gas rock and entered beds of sandstone and dark-brown and gray carbonaceous clay. The writer has seen very few cores from the Taylor well, but in the Rainey and Harris wells the clay is underlain by a thick section of igneous agglomerate and ash, and in the Rainey well the agglomerate is underlain by intrusive igneous rock. The interval between the base of the gas rock and the top of the volcanic agglomerate in the Rainey and Harris wells is about 100 feet.

The core material in both these wells is entirely different from any other thus far found in the area. Although there is no supporting paleontological evidence, these rocks are probably of Upper Cretaceous age.

The material in both wells, especially in the Harris, resembles clay laid down in quiet water, possibly a lake, into which some material derived from igneous rocks was carried. As this clay appears to be conformable with the underlying volcanic agglomerate in the Harris well it is likely that deposition of the clay followed the volcanic activity immediately. A possible explanation is that following the volcanic eruptions several craters were scattered over the top of the volcano and the clay may have been deposited in these. The cores of these wells are described on pages 36–39 and 45–46.

IGNEOUS ROCKS

Interbedded with the Mesozoic rocks below the gas rock in the Jackson gas field and cutting across their bedding are many bodies of igneous material, which have been reached in wells below a depth of 2,900 feet. In some of the wells the igneous material consists of ash that was blasted from active volcanoes during pre-Selma, probably Tuscaloosa time. In other wells only intrusive rocks have been found; that is, rocks that solidified without reaching the surface of the ground. In a few wells both ash and intrusive rock were found.

The intrusive rocks underlying the Jackson field include lamprophyre, a dark-colored granular dike rock having abundant mafic minerals; tinguaite, a fine-grained generally lighter-colored dike rock of the nepheline-syenite family; nepheline syenite; aplite; and sanidine-calcite rock. The ash found in some wells contains abundant small lapilli, spherical glassy pellets composed of radiating crystals.

The intrusive rocks were penetrated in the Gulf Refining Co.'s Hamilton, Rainey, and Hanna wells in sec. 4, T. 5 N., R. 2 E., sec. 13, T. 5 N., R. 1 E., and sec. 23, T. 5 N., R. 1 E., Rankin County, and the State of Mississippi's Fee No. 2 well in sec. 25, T. 6 N., R. 1 E. Ash was cored in the Gulf Refining Co.'s Rainey and McLaurin wells in sec. 13, T. 5 N., R. 1 E., Rankin County, and sec. 30, T. 6 N., R. 2 E., Hinds County, in the Louisiana Gas & Fuel Co.'s Harris No. 1 well, and in the Jackson Oil & Gas Co.'s Taylor No. 1 well, both in sec. 35, T. 6 N., R. 1 E., Hinds County. Igneous rocks that have not been studied were found in the Love Petroleum Co.'s Pearl River-Interior Lumber Co. No. 1 and Interior Lumber Co. No. 1 wells in secs. 15 and 28, T. 6 N., R. 2 E., Rankin County, and in the Marine Oil & Gas Co.'s Country Club Development Co. No. 1 well in sec. 31, T. 6 N., R. 1 E., Hinds County.

Detailed descriptions of the igneous rocks in the State of Mississippi's Fee No. 2 well have been published (Monroe and Toler, 1937, pp. 32–34, 40–52) and are not repeated here. The first igneous rock was cored in this well at a depth of 2,951 feet. In the published account of this well it is stated that extrusive igneous rock was penetrated at a depth of about 3,052 feet. Later studies have shown that this volcanic rock may be intrusive, so that the conclusions drawn by Monroe and Toler from the presence of volcanic rock below intrusive rock in the well are invalid. As understood at present no extrusive rock or ash is known from the State well.

C. L. Moody (1949) has recently discussed the relations of the igneous rocks at Jackson, Miss., to those found in other parts of the northern Gulf Coastal Plain. He concludes that the earliest intrusion—one apparently not represented at Jackson—was in Triassic time, and that this was followed by several periods of volcanism until middle Late Cretaceous time. The igneous activity at Jackson apparently took place early in Late Cretaceous time.

At the request of the writer Mr. Charles F. Park, Jr., studied the igneous rocks from the Hamilton, Rainey, Harris, and McLaurin wells. His report follows:

IGNEOUS ROCKS FROM DEEP WELLS AT JACKSON, MISSISSIPPI

By CHARLES F. PARK, JR.

Igneous rocks of hypabyssal character have been determined in two wells in the Jackson gas field. These are the Hamilton No. 1 and Rainey No. 1 wells. Sedimentary tuff beds occur in 2 other wells, the Harris No. 1 and the S. L. McLaurin, Jr., No. A–1.

The igneous rocks near Jackson, Miss., are possibly related to essentially similar rocks in adjacent parts of Arkansas (Monroe, 1933, pp. 38–51; Miser and Purdue, 1929, pp. 113–115; Purdue and Miser, 1923, pp. 7–8; Ross, Miser, and Stephenson, 1928, pp. 175–202; Williams, 1890; Croneis and Billings, 1930, pp. 149–162) and to late Cretaceous volcanism in Louisiana, Texas, and Oklahoma (Ross, Miser, and Stephenson, 1928, pp. 189–193).

HAMILTON NO. 1 WELL

Igneous rocks are found in the Gulf Refining Co.'s Hamilton No. 1 well in four places. Two textures are present—felsitic and, more commonly in the deeper rocks, finely granitoid. The fine granitoid rocks have the characteristics and habits of hypabyssal intrusives but it is not definitely known whether the finer textured materials are intrusive or extrusive. A tendency of the overlying and underlying sedimentary beds to be somewhat better consolidated than similar beds away from the igneous rocks suggests an intrusive origin. A few small tourmalines and garnets have been seen in some of the sedimentary materials but their occurrence gives no indication as to their origin. Sericite and some biotite are abundant in most of the sedimentary beds of the Cotton Valley (?) formation.

The first igneous rock was found in this well from a depth of 3,268 to 3,309 feet, a thickness of 41 feet. The rock, in hand specimen, is a light greenish-gray color and resembles a badly altered felsitic material of medium basic composition. A few dark gray phenocrysts, some about 5 millimeters in diameter, are present.

Under the microscope this altered rock is found to be composed largely of a mat of carbonates, sericite, chlorite, a member of the kaolin group, and small partly altered grains of a feldspathic constituent. Some biotite grains and corroded remnants of laths of acmite are preserved, and wedge-shaped areas of a yellowish colloidial material indicate the former abundance of titanite. The dark-gray phenocrysts of the hand specimen are represented in thin section by polygonal, usually hexagonal, shaped areas composed mostly of fine-grained carbonates and a kaolin mineral. These fine-grained particles are arranged in rude concentric zones. The centers of some of the phenocrysts are composed of analcite with finely divided iron oxides, others consist of a very fine, partly altered subgraphic intergrowth of orthoclase(?) and nephelite(?) which retains a pale pink or purple tint. The phenocrysts may originally have been a mineral of the sodalite group, or possibly leucite. Orthoclase is fairly common throughout the rock and some of the small grains of iron oxides—probably ilmenite—are abundant. Many small square and hexagonal shaped grains are scattered throughout the groundmass. These grains are usually either dusty or altered to a carbonate but probably were nephelite in the unaltered rock. A few small groups of very fine radiating needles—probably natrolite—are also present.

Essentially similar igneous material is found in the well from a depth of 3,376 to 3,399 feet. The rock is porphyritic; the greenish gray felsitic groundmass contains numerous darker gray phenocrysts which in places measure as much as 1 centimeter diagonally. Much of the rock is somewhat fresher than the first igneous material found in the well. In thin section some of the larger phenocrysts show fine concentrically developed cracks near the grain borders. Analcite is especially common and in the available material makes up nearly 25 percent of the rock. This mineral appears to be pseudomorphous after both nephelite and the sodalite mineral(?) or leucite(?). Some of the analcite is associated with and partly altered to carbonates, a minute subgraphic intergrowth, a mineral of the kaolin group, and spots and fine dendrites of iron oxides. Some pyrite is also formed.

Similar igneous rock is again found in the well from a depth of 3,433 to 3,492 feet. Below a depth of 3,488 feet part of the core has a fine granitoid texture. The contact between these different textured rocks is gradational through a distance of several millimeters but has furnished no conclusive information concerning the relationships between the two types.

The groundmass of the felsitic type consists of a fine-grained aggregate of carbonates, sericite, a kaolin mineral, and a very fine micrographic intergrowth of feldspathic constituents. Orthoclase is present in all of the material and, as in the rocks previously mentioned, is comparatively unaltered in many places. Analcite is conspicuous and is associated locally with a fine intergrowth of nephelite(?) and orthoclase, the tiny needles of the intergrowth being oriented at approximately 90°. Some of the least altered analcite grains are clouded by a latticelike arrangement of minute iron oxide particles that have a general tendency to accumulate near the centers of the analcite grains.

The fine granitoid part of the core from 3,488 to 3,492 feet is composed largely of dusty orthoclase; much of the orthoclase is twinned according to the Carlsbad law. Rounded areas several millimeters in diameter are numerous. These areas have a brownish color and consist of a fine aggregate of alteration products in which sericite, carbonates, and a featherlike mineral, probably a zeolite, are noticeable. A few grains of fresh titanite and small needles of apatite are also seen.

The least altered igneous rock in the Hamilton well was obtained from a depth of 4,024 feet to the bottom of the boring at 4,027 feet. The hand specimen is a dark greenish-gray color, indistinctly mottled with reddish brown. The rock is dense and has the greasy appearance characteristic of the nephelite-bearing series. The texture is fine granitoid with phenocrysts of nephelite and a few large melanite garnets conspicuous in thin section. The rock is estimated to contain about 35 percent orthoclase, 25 percent nephelite, 15 to 20 percent combined, acmite-augite and acmite, 15 to 20 percent analcite, and 5 percent of accessory constituents, including melanite garnet, titanite, apatite, and ilmenite.

The orthoclase is commonly in grains not more than 1 millimeter long and usually less than 0.5 millimeter. It is complexly twinned along irregular surfaces instead of distinct planes. Many of the grains have a wavy extinction, and the crystal outlines are very irregular. Inclusions of small crystals of nephelite are also common.

Nephelite is present in well formed phenocrysts and also in smaller grains throughout the slide. The phenocrysts are usually rectangles not more than 1.5 millimeters in longest dimension. The mineral is a pale pink color and is commonly surrounded by a thin layer of brownish colloidal alteration products. Some of the nephelite is altered to analcite and carbonates and small amounts of cancrinite(?) are formed near the borders of and along cracks through grains of nephelite.

Analcite is a common alteration product of nephelite and is especially abundant in the finer material. The numerous small rectangular grains as well as the larger crystals of nephelite partly replaced by analcite indicate that the analcite was not an original constituent of the rock but was formed at a later period. Analcite is usually associated with and appears to be altering to carbonates.

Acmite-augite is present in lath-shaped grains which with few exceptions are smaller than 2 millimeters by 0.5 millimeter. The centers of some of the larger grains retain small nuclei of a colorless pyroxene, probably augite, which has a normal extinction angle ($Z \wedge c$) of about 48°. Near the borders of the acmite-augite grains thin layers of acmite are formed and some of the smaller grains are entirely composed of acmite. The pleochroic formula of the acmite-augite may be expressed X=clear (light) green, Y=greenish yellow, Z=pale brownish yellow. The acmite is X=deep grass green, Y=yellowish green, Z=brownish green. Acmite is also formed in narrow aureoles around corroded grains of melanite garnet.

The observed accessory constituents consist of four minerals, a dark brown melanite garnet, titanite, apatite, and iron oxides, probably ilmenite. The melanite garnet is in corroded grains; the most common crystal form resembles a cube with the corners but slightly beveled. The largest grain observed measures about 2 millimeters across. The garnet crystals are surrounded by a narrow zone of acmite and usually some carbonates. Titanite is scattered throughout the rock in well-formed diamond-shaped crystals and wedges, wherever seen less than 0.5 millimeter in longest dimension and usually less than 0.25 millimeter. Titanite, as the melanite garnet, is commonly surrounded by a thin zone of acmite. Apatite is an abundant constituent and commonly occurs in very fine needlelike crystals. A few of the grains are about 0.5 by 0.1 millimeter, although usually much smaller and finer. A small number of iron oxide grains, probably ilmenite, are present.

Carbonates are scattered throughout the rock and form a common alteration product. Small quantities of pyrite, fluorite, and a very little secondary quartz are also present.

RAINEY NO. 1 WELL

Igneous rock was first found in the Gulf Refining Co.'s Rainey No. 1 well from a depth of 2,936 to 2,940 feet. The rock in the hand specimen is a light chocolate color and appears to be composed almost entirely of one feldspathic constituent. The texture is granitoid with the grains interlocking. In thin section the rock is found to be about 90–95 percent feldspar, mostly sanidine with a small quantity of albite. Intersertal quartz makes up 5 to 10 percent of the rock. The optic angle of the sanidine is small (estimated at $-20°$). The indices are $\alpha=1.518$, β=undermined, $\gamma=1.523$. Carlsbad twinning is common and a few Baveno twins are present. Most of the feldspars are slightly clouded by a mineral of the kaolin group, and a little carbonate is developed. The only other constituents seen are small apatite crystals and a fine yellowish white powder arranged in a few wedge-shaped grains which were probably titanite. The rock is thought to be a minor hypabyssal type.

Above this sanidinite is a thin-bedded carbonaceous shale which contains considerable calcareous material. A few small pebbles are present and some of the finer constitutents are angular. Biotite is conspicuous. The carbonaceous shale changes upward into the sands and clays of the Tuscaloosa (?) group.

From a depth of 2,940 to 2,979 feet the exact nature of the rock is not known. Some of the core appears to be clay which contains numerous small pebbles mostly of volcanic and siliceous character. Other parts of the core contain coarse biotite grains, and although the matrix is clay, a suggestion of granitoid texture is retained. It is probable that both sedimentary and igneous rocks are present in this core which is considered to be from a highly altered contact zone.

Between the depths of 2,979 to 2,988 feet the rock resembles an altered coarse tuff. The fragments are both well-rounded and angular; they are mostly of altered igneous rock in which the mineral pseudomorphs suggest flow banding or alinement. Carbonates, chlorite, sericite, and iron oxide are abundant and fragments of biotite, a greenish brown hornblende, and some apatite, as well as dusty outlines of titanite crystals are recognizable.

At a depth of about 2,988 feet the drill again entered igneous rock which persisted, so far as shown by the available core, to the bottom of the well at a depth of 3,607 feet. This rock consists of two types—one felsitic (porphyritic) and the other of granitoid texture. The exact relationships between these two types of rock are not known. One piece of core contains both types of material but even in thin section the contact is a straight sharp line which has yielded no clues as to origin or relationships. Near the upper contact the igneous rock has been so thoroughly altered that little information of value can be obtained from it.

The granitoid rock is an alkalic lamprophyre. It consists of pyroxene 20 to 30 percent, sericitized areas which were probably nephelite but possibly in part feldspars ±20 percent, biotite 15 to 20 percent, titanite 10 to 20 percent, ilmenite ±10 percent, sanidine 5 to 10 percent, basaltic hornblende 0 to 5 percent, and apatite which may make up as much as 2 or 3 percent of the rock.

The pyroxene varies in size from minute inclusions to crystals as much as 1 centimeter long. The crystals are lath shaped in thin section (plates in the hand specimen), usually about 3 times as long as wide. The average optic angle is estimated at about 40° and the optical character appears to be always positive. The maximum extinction angle ($Z \wedge c$) in the large grains is 36°, in the smaller inclusions $Z \wedge c=41°$. The pyroxene is probably near pigeonite. Much of the pigeonite is titaniferous; the pleochroic formula may be written X= light red, Y=yellowish red, Z=red. Near the borders of many of the grains the titanium decreases and the sodium increases; the pigeonite varies from a decided pink to a clear green color and it approaches acmite-augite. The titaniferous pyroxene in most places contains many very fine needles, probably rutile. Where the titaniferous pyroxene changes to the sodic variety the rutile decreases and in the green pyroxene is entirely wanting. All the pyroxene contains inclusions which are, in addition to the rutile, smaller pyroxene grains, apatite, ilmenite, and titanite. In some grains the inclusions are very abundant.

The sericitized areas cannot be determined with absolute certainty. In places they are veined by fresh-appearing orthoclase. Well-formed hexagonal and rectangular cross sections are common in the orthoclase and strongly suggest the former presence of nephelite.

Biotite varies in size from plates several millimeters in diameter to very tiny crystals. The pleochroism is extreme, X=pale straw yellow, Y=brown, Z=black with a shade of green. Biotite appears to be one of the early constitutents of the rock and numerous individual crystals are partly cut or completely divided by titanite, basaltic hornblende, apatite, and pigeonite.

Some of the rock contains exceptional quantities of titanite, usually but not always in well-formed crystals. The mineral in the hand specimen has a vitreous buff to yellow color. Inclusions of apatite, pyroxene, and ilmenite are common.

Ilmenite is a common accessory mineral throughout the igneous rocks. It occurs in irregularly shaped grains, the larger frequently inclosing crystals of apatite and also a few small grains of pyroxene. Indistinct parting planes are developed in some of the areas.

Orthoclase is scattered throughout the rock in small areas. Usually this feldspar is fresh and in some slides appears to form veinlets through the altered nephelite. Small inclusions are also common in the orthoclase.

Basaltic hornblende forms as much as 5 percent in some of the rock slides, in others it is entirely absent. The extinction angle ($Z \wedge c$) is commonly between 10° and a maximum of 16°, a high angle for basaltic hornblende. The amphibole may be near barkevikite in composition. The pleochroic formula is X=straw yellow, Y=reddish brown, Z=dark reddish brown. Inclusions of apatite, pyroxene, and titanite are common.

Apatite is a common and rather homogeneously distributed accessory constituent. The crystals frequently contain minute centrally placed grains of biotite, pyroxene, and ilmenite. A few of the apatite grains are hollow; the sides of the hollow core parallel the external sides of the hexagonal crystals.

Especially in the upper core the igneous rocks are badly altered. Pyrite is common, even in the freshest specimens, and a few crosscutting veinlets of carbonates are also usually present. The ferromagnesian constituents alter to chloritic material, carbonates, sericite, and small amounts of epidote; the feldspathic minerals change to a mat of sericite, a mineral of the kaolin group, and carbonates. Talc and serpentinous alteration products probably are also present but have not been distinguished from chlorite and sericite. Titanite alters to a yellowish-white colloidal aggregate and to carbonates. Apatite locally changes to carbonates. Probably some deuteric biotite developed after the main rock was formed, and even in the most altered of the igneous rocks some biotite is preserved.

The fine-grained igneous cores are so badly altered and decomposed that the original character is in doubt. The texture was originally porphyritic and in one slide some large corroded crystals of orthoclase are partly preserved. The phenocrysts are usually altered to a fine aggregate of sericite needles but carbonates and chalcedonic silica are present in a few places. The groundmass may be altered and devitrified glass; no suggestion of flow structure is seen. Some fine-grained biotite and apatite are recognizable but the main matrix of the rock consists of a minute aggregate of carbonates, chlorite, sericite, and other alteration products. Some yellowish-white colloidal particles in wedge- or diamond-shaped areas may represent former titanite crystals and a few subrounded spots of a kaolin mineral suggest either a mineral of the sodalite group or leucite. In one slide the very fine matrix appears to be partly arranged in a subgraphic pattern. Pyrite is present in all the material examined. One slide contains several angular fragments of an altered volcanic rock, the former crystals of which are alined and suggest an original flow structure. Owing to the fact that the felsitic rock is found from a depth of 3,035 to 3,600 feet the rock is considered more likely a minor intrusive than a flow although the evidence is admittedly inconclusive.

HARRIS NO. 1 WELL

From a depth of 2,973 to 2,975 feet in the Louisiana Gas & Fuel Co.'s Harris No. 1 well there is a transition zone from the overlying shale and sandstone of the Tuscaloosa(?) group to an underlying series of clastic volcanic materials. The transition is marked by the presence, in a clay or shale matrix, of pebbles and angular fragments which increase in number downward. The clastic materials persist with only minor variations from 2,975 feet to the bottom of the well at 3,239 feet, a total thickness of 264 feet, with the lower contact not found.

The matrix of the clastic volcanic materials is commonly clay, usually soft and poorly consolidated, but in some places indurated to a more compact mass. In a few specimens the texture of the groundmass suggests an extreme alteration, in situ, of an original volcanic rock. In most places, however, the clay is thought to have been deposited originally as clay which contained a heterogeneous mixture of mineral and rock pebbles and fragments. Finely divided carbonaceous material is present in the groundmass of some of the specimens, and in others holes that resemble vesicules are seen.

The pebbles and fragments, seen only in the drill cores, are never more than 1 inch in longest dimension and grade from this down to a submicroscopic size. The shapes are extremely variable, and well-rounded pebbles are closely associated with both subangular and sharply angular fragments. Bedding planes are practically absent except in a few cores where clays greatly predominate and alternating paper-thin bands of light and dark clays, in some places contorted, are seen. Many of the particles are surrounded by rims of dusty alteration products.

The composition of the megascopic particles is variable but they consist mainly of igneous rock, limestone, quartzite and sandstone, and small quantities of shale. The cores are all intensely altered; carbonates are especially abundant, and some of the specimens are almost completely changed to calcite. Chloritic materials, sericite, sulfides, iron oxides, and biotite are commonly present, and a little chalcedony is seen. Numerous areas of finely divided alteration products are present, but no effort has been made to determine the individual constituents. The igneous rock particles are usually so badly altered that their original composition is obscured. Some of them retain pseudomorphs of needlelike crystals which are alined and suggest flow structure. A few of the igneous rock fragments apparently had a fine granitoid texture; others are highly inflated and possibly represent volcanic ejecta. The limestone particles are commonly crystalline but some have retained sufficient carbonaceous material to impart a dark gray color to the specimens. Fragments of orthoclase are recognizable and some contain small rectangular and hexagonal plates which resemble nephelite, although the crystals are too badly altered to enable identification. A few pieces of the orthoclase are being replaced near their borders by introduced quartz which forms a myrmekitic type of intergrowth with the feldspar. Titanite and apatite are both fairly common but are partly or completely altered to a yellowish-white powder (after titanite) and carbonate. One well-shaped crystal of colorless garnet (grossularite?), about 2 millimeters in diameter, is present. This garnet is thought to be of extraneous origin and not formed in the clastic rock. Biotite appears to be especially well preserved and broken plates about 5 millimeters in greatest dimension are common. Biotite is also apparently forming as small shreds in many of the rock particles.

The clastic rock is, basically speaking, a sedimentary type, poorly sorted, and containing much volcanic debris. It may be classified as a water-laid tuff which contains many well-rounded (water-worn) particles.

MCLAURIN NO. A–1 WELL

Tuffaceous material, essentially similar to that encountered in the Harris No. 1 well, has been cored in the Gulf Refining Co.'s McLaurin No. A–1 well in the last 8 feet of the boring (2,942 to 2,950 feet). The tuff contains angular fragments of dark-colored altered felsitic igneous rocks, quartz, and augite altering to a dark-green hornblende. The tuff is very badly altered to an aggregate which consists mainly of carbonates, sericite, chloritic material, and iron oxides.

SELMA GROUP

Directly overlying and truncating the edges of the pre-Selma rocks is a deposit of very pure calcium carbonate, limestone, and earthy chalk that is correlated with portions of the Selma group. The Study Group of the Mississippi Geological Society (Wedel and others, 1941, pp. 2, 3) divides the Selma group into a "Gas-rock" facies and a "normal Selma" facies. The "Gas-rock" facies intertongues with and was deposited coincidently with the upper part of the normal Selma and is believed to be entirely of Navarro age (very late Cretaceous). Within the area described in this report only the "Gas-rock" facies is present except possibly in the easternmost part. The writer has not studied cores and cuttings from any of the wells drilled through the normal Selma facies. In general it may be said that the normal facies consists of more or less earthy limestone and chalk and calcareous shale.

The name "chalk" is scarcely appropriate for the rock at Jackson because the chalk of the Selma group in northeastern Mississippi and central Alabama contains much more clay, sand, and other impurities than the rock drilled at Jackson. Some beds at Jackson are hard, crystalline pure limestone and others are made up of very soft pure calcium carbonate that resembles chemically precipitated chalk. Small cavities at several depths caused difficulty in drilling because the drilling mud flowed into the rock and failed to return to the surface. Many of these cavities are lined with calcite crystals. Cores from the gas rock are described at the end of this section of the report. The name "gas rock" has been commonly used for this material because gas was produced from it in the Monroe gas field in Louisiana before its stratigraphic relations were understood.

According to the Study Group report the "Gas-rock" facies ranges in thickness from 30 feet near its northeastern limits to 1,350 feet near the axis of the Embayment syncline.

Most of the wells drilled in the Jackson area stop either at the top of the gas rock or in the overlying Clayton formation, whichever is the gas-producing zone. Munroe (1935, p. 890) says that "the reservoir is the unconformity zone between the Midway chalk and Cretaceous chalk and the solution (?) cavities in the top of the Cretaceous chalk."

On the crest of the anticline the gas rock appears to rest directly on sandstone and claystone of the Cotton Valley (?) formation except in the basins that contain the clay penetrated in the Rainey and Harris wells. On the flanks of the anticline the gas rock rests on the eroded edges of formations of the Tuscaloosa group near the crest and on the Eutaw formation farther down the flanks.

Very few fossils have been found in the gas rock, but those found suggest that it is of Navarro, possibly Prairie Bluff age. R. D. Norton, paleontologist of the Texas Co. found many Upper Cretaceous Foraminifera in the chalk in the Lion Oil Refining Co.'s Misterfeldt No. 1 well in sec. 2, T. 4 N., R. 1 E., Rankin County. He submitted a core sample from a depth of 3,480 to 3,491 feet to T. W. Vaughan who found a new genus of an orbitoid foraminifer *Lepidorbitoides* (*Asterorbis*) *rooki* Vaughan and Cole, *Hamulus* sp. indet., and *Orbitocyclina nortoni* Vaughan (Vaughan and Cole, 1932, pp. 611–613). Dr. Vaughan was unable to determine the age more definitely than late Cretaceous. The top of the Clayton formation in the Misterfeldt well was encountered at 3,064 feet and the top of the gas rock was probably reached at some depth between 3,069 and 3,081 feet. The contact between the Clayton and the gas rock is difficult to determine, and the top of the Clayton is the structure horizon commonly used in the area. The top of the core containing *Lepidorbitoides* is 416 feet below the top of the Clayton.

Lepidorbitoides (*Asterorbis*) *rooki* was also identified from cores taken in the Union Producing Co.'s Anderson No. 1 well in sec. 12, T. 8 N., R. 1 W., Madison County, 16 miles north of Jackson. The Foraminifera are abundant in cores taken between 4,455 and 4,515 feet and a few are present in cores taken between 4,545 and 4,587 feet. The top of the Clayton formation in the Anderson well was reached at about 4,348 feet. *Lepidorbitoides* is present, then, from 107 to 239 feet below the top of the Clayton. Whether the upper part of the gas rock is missing in Madison County or whether *L.* (*A.*) *rooki* has a long range in the pure chalk is not known. *Lepidorbitoides rooki* has been found associated with *Orbitocyclina nortoni* in the Monroe gas rock at Monroe, La., and M. C. Israelsky (written communication February 6, 1941) believes that the Monroe gas rock is of Navarro age. Several geologists have suggested informally that the gas rock may be equivalent to the Prairie Bluff chalk. The great unconformity beneath the gas rock at Jackson may well be a part of the Gulf-wide unconformity beneath the Prairie Bluff and its equivalents.

Drs. Bassler and Ulrich identified an Upper Cretaceous coral, *Heliopora* sp., and noted indeterminate Bryozoa in a core from depths of 2,865 to 2,878 feet in the Gulf Refining Co.'s Hamilton No. 1 well, sec. 4, T. 5 N., R. 2 E., Rankin County.

The fossil species present in the gas rock and the lack of sand or clay all confirm the belief that the gas rock was deposited in extremely clear, only moderately deep water. Most geologists in Mississippi believe that the rock represents a series of reef deposits in water that was clearer than that where the earthy normal Selma was deposited.

ROCKS OF TERTIARY AGE

PALEOCENE SERIES

MIDWAY GROUP

CLAYTON FORMATION

Originally the top of the calcareous rocks beneath the Porters Creek clay (the "black shale" of the drillers) was considered the top of the Cretaceous (Monroe, 1932, pp. 3, 4, 6), but more careful study of fossils contained in cores has proved that the uppermost few feet of this limestone is of Paleocene age, probably the Clayton formation. Because of a lithologic resemblance of the Clayton to the gas rock it is very difficult to determine the contact. The Clayton ranges in thickness from a very few feet to as much as 30 or possibly 80 feet in different parts of the area.

The Clayton formation consists of hard gray and white limestone containing shell fragments, foraminifers, and stems of nullipores (calcareous algae). This kind of limestone merges upward into a rock composed of shells, limestone, and black clay; at the top is very hard black calcareous clay or argillaceous limestone filled with shell fragments. The contact between the Clayton formation and the overlying Porters Creek clay is sharp, but the two formations appear to be conformable.

Dr. L. W. Stephenson (written communication, July 6, 1932) examined a specimen blown out of Meredith and Smith's Strawder No. 2 well, sec. 12, T. 5 N., R. 1 E., Rankin County, sent to the Geological Survey by Robert L. Steffey, Jackson, Miss. Stephenson's report on this specimen follows:

The rock contains the internal and external molds of many fossils. The most abundant form is a small *Meretrix*-like shell belonging in the family Veneridae; this shell is plump with strong concentric sculpture and is probably an undescribed species. A fragment of an echinoid, presenting an interior view, and an echinoid spine are scarcely adequate for identification. The small apical portion of a *Turritella* has not as yet been matched with any known species. One small *Natica*-like gastropod and a small fragment of a crustacean were observed. No organism suggestive of the Cretaceous age of the rock was observed. Both the lithology and the fauna appear to me to be more suggestive of Tertiary than Cretaceous.

Mr. L. G. Henbest (written communications, August 17, 1932 and December 7, 1935) examined a core taken at a depth of 2,396 to 2,398 feet from the Gulf Refining Co.'s Hartfield No. 1 well, sec. 7, T. 5 N., R. 2 E., Rankin County, consisting of hard black argillaceous limestone filled with fragments of pelecypod shells and algae. Henbest's report follows:

By crushing and alternately heating and quenching the specimen I was able to recover a few specimens of foraminifera from this indurated, impure, limestone. Among the foraminifers are a few specimens of *Robulus midwayensis* (Plummer). These are not conspicuously typical specimens, but are unlike any of the related Navarro forms that I have seen. I do not regard this evidence as conclusive and would therefore state the age as Midway(?).

The rock contains numerous, rounded fragments of *Lithothamnium* (more commonly known as nullipores) which are calcareous algae. *Lithothamnium* is known both from the Cretaceous and Cenozoic.

A core taken from a depth of 2,501 to 2,511 feet in the Gulf Refining Co.'s Rainey No. 1 well, sec. 13, T. 5 N., R. 1 E., Rankin County, consists of hard white and dark-gray limestone filled with fragments of shells and stems of calcareous algae. Other cores from the Clayton formation are described on pages 35 and 36.

It seems likely that the Clayton formation in wells at Jackson consists largely of limestone and chalk reworked from the gas rock, supplemented by an abundance of calcium carbonate in solution or suspension derived from the pure chalk plain that the sea transgressed in Clayton time. A large amount of black clay is also present in the cores, for the Clayton is not so pure a limestone as the gas rock.

PORTERS CREEK CLAY

The Porters Creek clay overlies the Clayton formation. Although the rather sharp contact is easily recognized by drillers, the two formations are believed to be conformable. In support of this view it may be pointed out that hard calcareous layers in the Porters Creek have often been mistaken by drillers for the "cap rock" or top of the Clayton.

The Porters Creek clay consists of black, sparingly micaceous clay, fossiliferous and calcareous in the lower half and only sparingly fossiliferous and calcareous in the upper half. The formation ranges in thickness, according to well logs, from about 75 feet to 800 feet. Its thickness averages about 100 feet on the top of the anticline but increases on the sides, especially toward the south.

Several species of foraminifers have been identified by Mr. Henbest in cores from the Porters Creek clay; the species suggest that the Porters Creek on the crest of the anticline is of late Midway age. The species are listed in the detailed descriptions of cores. It seems likely that in early Midway time the Jackson area was an island in the sea. Later the land gradually sank, probably by tilting toward the Gulf, and the upper Midway sea was able to cover the top of the island to a depth of a hundred feet or more. This is further borne out by the much greater thickness of Midway group in the wells south of Jackson, notably in the Benedum-Trees Oil Co.'s Southern Minerals Development Corp. No. 1 well in sec. 35, T. 3 N., R. 1 E., Rankin County, which was drilled through about 800 feet of black clay of the Midway, probably all Porters Creek. It seems likely that only the upper part of the Midway in this well is present on the crest of the anticline.

EOCENE SERIES

WILCOX FORMATION

The Wilcox formation consists of gray micaceous, lignitic, fine sand and clay overlain by light-gray and brown micaceous sandstone and calcareous sandstone, overlain in turn by gray sand and clay and lignite. Scattered layers or concretions of siderite have been cored, particularly in the lower part of the group. The Wilcox near Jackson averages about 1,250 feet in thickness, but in the southern part of the Jackson area it is probably thicker than 2,500 feet.

Samples from the Wilcox formation have been examined from only two wells in the area, the Lion Oil & Refining Co.'s Misterfeldt No. 1 well in sec. 2, T. 4 N., R. 1 E., Rankin County, and the Louisiana Gas & Fuel Co.'s Harris No. 1 well in sec. 35, T. 6 N., R. 1 E., Hinds County.

CLAIBORNE GROUP

Unconformably overlying the Wilcox formation is the Claiborne group which consists of soft glauconitic limestone or marl, sand, clay, and lignite. The total thickness of the group on the crest of the anticline is about 1,100 feet, but it is probably much thicker in the southern part of the area. The writer has examined samples of the Claiborne group from only a few wells. Plate 5 is a generalized composite section incorporating information derived from these samples and from drillers' logs.

DESCRIPTIONS OF CORES AND CUTTINGS FROM WELLS

Fairly complete suites of samples have ben examined from 6 deep, oil and gas, test wells in the Jackson area and a few scattered samples from about 12 other wells. In the following pages samples from 6 of these wells are described in detail. The samples are from cores except as noted otherwise.

A detailed description of the samples from the Fee No. 2 well of the State of Mississippi, sec. 25, T. 6 N., R. 1 E., Hinds County, by Monroe and Toler (1937, pp. 27–52) is not repeated here, as the bulletin in which the description was published is readily available. Likewise descriptions by R. D. Norton of the Texas Co. of the samples to a depth of 3,491 feet in the Misterfeldt No. 1 well of the Lion Oil and Refining Co. in sec. 2, T. 4 N., R. 1 E., Rankin County (Monroe, 1932b, pp. 5–6) are not repeated here although the samples from depths of 3,480 to 4,075 feet are now described because the description has not hitherto been published.

Toole No. 1 well. Drilled by Louisiana Gas & Fuel Co.

[704 feet north and 278 feet east of the southwest corner SE¼ sec. 28, T. 6 N., R. 1 E., Hinds County; altitude, 304 feet]

	Depth at which sample was obtained (feet)
Jackson group: Clay, tan, silty, calcareous (bit sample)	12–29
Claiborne group:	
Clay, light-brown, carbonaceous, micaceous, very finely sandy	270–272
Clay, light-gray, silty, micaceous, noncalcareous containing very small, flattened pieces of lignite	272–275
Sand, slightly indurated, thin-bedded, light- and dark-gray, slightly calcareous, silty, fine-grained; a little glauconite	275–276
Clay, light brownish-gray, silty, micaceous, carbonaceous, noncalcareous	281–282
Sand, crossbedded, gray, fine-grained, and brownish-gray silty clay; contains mica, lignite, and a few glauconite grains	282–284
Sand, silty, micaceous, fine-grained; containing thin beds of carbonaceous sand	297–311
Clay, light-brown, silty, micaceous, carbonaceous	311–313
Sand, medium brownish-gray, micaceous, silty, fine-grained	315–319
Sand, carbonaceous, fine-grained, many large flakes of mica	321–323
Sand, thin-bedded, gray, micaceous, glauconitic, carbonaceous, fine-grained; and brown carbonaceous, micaceous, silty clay; glauconite in sand is in fine grains and is very pale	325–326
Clay, grayish chocolate-brown, micaceous, slickensided	326–327
Clay, compact, horizontally bedded, slightly carbonaceous, noncalcareous	327–329
Sand, slightly glauconitic, fine and very fine grained; and brown, silty clay like above	330–331
Sand, white, micaceous, sparingly calcareous, subangular, fine-grained	771–772
Sand, geenish-gray, silty, glauconitic, micaceous, slightly calcareous, clayey, fine-grained	773–774
Sand, well-rounded, medium-grained; abundant glauconite, some in round nodules	774–775

Toole No. 1 well. Drilled by Louisiana Gas & Fuel Co.—Continued

	Depth at which sample was obtained (feet)
Claiborne group—Continued	
Sand, micaceous, clayey, subangular, fine-grained, and silty clay; glauconite scarce	776–777
Sand, micaceous, glauconitic, very slightly calcareous; a little brown mica and carbonaceous matter	778–781
Clay, grayish-brown and gray, silty, micaceous, calcareous, sparingly glauconitic, finely sandy (bit sample)	790
Clay, medium grayish-brown, silty, micaceous, glauconitic, calcareous, finely sandy (bit sample)	834
Silt, thin-bedded, light-gray, micaceous, finely and sparingly glauconitic; and grayish-brown silty clay	834–839
Clay, very finely crossbedded, light-gray, silty, sparingly carbonaceous, noncalcareous	839–840
Silt, thin-bedded, light-gray, finely micaceous, clayey	840–841
Silt, light brownish-gray, micaceous, clayey, containing small flattened twigs or lenses of carbonaceous matter and small, elongate lenses or tubes of light-gray, micaceous silt	841–842
Clay, thin-bedded, light grayish-brown, silty; and light-gray micaceous silt; many small tubes or borings filled with light-gray silt	842–847
Chalk, white, coarsely glauconitic, micaceous, fossiliferous, or soft marly limestone	1, 062–1, 074
Clay, brown, calcareous, slightly glauconitic	1, 104–1, 106
Chalk or marl, white, finely glauconitic, micaceous, fossiliferous	1, 106–1, 114
Sandstone, compact, gray, micaceous, fossiliferous, slightly calcareous, sparsely glauconitic, very fine grained	1, 115–1, 130
Silt, micaceous, slightly calcareous, fine, sandy	1, 131–1, 133
Clay, pale green, sparingly glauconitic, calcareous, fossiliferous, finely sandy	1, 134–1, 135
Limestone, fossiliferous, glauconitic	1, 137–1, 138
Silt, greenish-gray, calcareous, fossiliferous, glauconitic	1, 138–1, 139
Sand, pale-green, glauconitic, slightly calcareous, very fine grained	1, 141–1, 142
Sand, micaceous, glauconitic, fossiliferous, silty, well-rounded, fine-grained	1, 143–1, 144
Wilcox formation (?):	
Sand, light grayish-brown, silty, micaceous, clayey, slightly carbonaceous, fine grained	1, 144–1, 148
Sand, light-gray, micaceous, slightly carbonaceous, very fine grained; one indeterminate print of a mollusk	1, 148–1, 151
Silt, very light gray, micaceous, slightly calcareous	1, 152–1, 153
Clay, light-gray, carbonaceous, containing lenses of fossiliferous, glauconitic sand; some of carbonaceous matter contains much pyrite	1, 153–1, 154
Sand, glauconitic, micaceous, fossiliferous	1, 155–1, 156
Silt, laminated, micaceous, very slightly calcareous	1, 158–1, 159
Clay, light grayish brown, silty, carbonaceous; a few grains of glauconite (bit sample)	2, 280

Toole No. 1 well. Drilled by Louisiana Gas & Fuel Co.—Continued

	Depth at which sample was obtained (feet)
Porters Creek clay:	
Clay, black, noncalcareous, containing a little mica and pyrite	2,419–2,421
Clay, very dark gray to black, noncalcareous; a piece of white heavy sandstone, containing black grains	2,421–2,423
Clay, black, noncalcareous, containing pyrite and indeterminate molluscan shells	2,423–2,433
Clay, black, noncalcareous, containing indeterminate fossil shells and a little pyrite	2,475–2,484
Siderite, dark-gray, containing a large lens of pyrite	2,484–2,485
Clay, dark-gray to black, horizontally bedded, noncalcareous, shaly, containing scattered fossil shell fragments	2,485–2,496
Clay, dark-gray to black, containing abundant fossil shell fragments	2,496–2,497
Clayton formation:	
Limestone, hard, fossiliferous	2,499–2,501

Harris No. 1 well. Drilled by Louisiana Gas & Fuel Co.

[1430 feet west and 180 feet north of the southeast corner sec. 35, T. 6 N., R. 1 E., Hinds County; altitude, 282 feet]

	Depth at which sample was obtained (feet)
Claiborne group:	
Sand, brownish-gray micaceous, silty, very fine grained	200–204
Sand, light-gray, micaceous, noncalcareous, very fine grained	204–208
Sand, thin-bedded, light-gray, micaceous, very fine grained, and brownish-gray silty clay; some comminuted carbonized plant remains	208–214
Sand, gray, micaceous	249–250
Sand, micaceous, carbonaceous, angular, fine grained	250–251
Sand, brown, micaceous, fine grained, and brown silty clay	251–252
Sand, gray; and brown micaceous, carbonaceous clay	252–253
Clay, brown, micaceous, silty, carbonaceous; contains abundant small ellipsoidal pellets of clay about 1 mm long and 0.5 mm in diameter (fecal pellets?)	253–254
Clay, brown, micaceous; a little very fine grained sand	254–255
Clay, light-brown, very finely micaceous, carbonaceous, silty; thin tube of gray, very fine grained sand horizontal in core	255–260
Sand, glauconitic, subangular, fine- to medium-grained, in a matrix of light-brown noncalcareous clay; small lumps of brown clay; no fossils; glauconite appears to be reworked	260–261
Clay, thin-bedded, brown, silty, micaceous, carbonaceous; lenses of sand	261–262
Sandstone, white, micaceous, fossiliferous, calcareous	330–332
Sandstone, similar, with lignite	332–333
Sandstone, light-brown, glauconitic, micaceous, fossiliferous, calcareous	333–335
Limestone, gray, sandy, glauconitic, micaceous, fossiliferous	335–338
Clay, gray, silty; a few grains of carbonaceous matter	906–907
Limestone, soft, coarsely glauconitic; soft macrofossils including *Pecten* sp.; micaceous and slightly sandy in some beds	995–1,009

Harris No. 1 well. Drilled by Louisiana Gas & Fuel Co.—Continued

	Depth at which sample was obtained (feet)
Wilcox formation:[1]	
Clay, brownish-gray, sandy	1, 068–1, 328
Sand, gray, and sandstone	1, 329–1, 350
Clay, hard, gray	1, 350–1, 365
Sand, gray, and clay	1, 365–1, 395
Sand, gray, clayey	1, 395–1, 410
Clay, gray, sandy	1, 410–1, 455
Sand, gray, micaceous clayey	1, 455–1, 470
Sand, light-gray, silty, micaceous, clayey, very fine grained	1, 470–1, 485
Sandstone, light-gray	1, 485–1, 500
Sandstone, gray, micaceous, pyritiferous, slightly calcareous fine grained	1, 500–1, 530
Sand, light-gray, clayey	1, 530–1, 545
Sandstone, gray, micaceous, pyritiferous, slightly calcareous, fine-grained	1, 560–1, 565
Sand, fine-grained, subangular	1, 575–1, 590
Sand, clayey, fine-grained	1, 500–1, 605
Sandstone, gray, micaceous, pyritiferous, fine-grained, calcareous	1, 620–1, 720
Clay, light-gray, silty	1, 720–1, 735
Sand, light-gray, silty, micaceous, clayey, iron-stained, very fine-grained	1, 735–1, 780
Sand, ferruginous, fine-grained, subangular	1, 780–1, 810
Sand, light-gray, micaceous, clayey	1, 810–1, 825
Sandstone, brown, ferruginous, fine- and subangular-grained; thin plates of ironstone	1, 825–1, 840
Silt, light-gray	1, 855–1, 900
Sand, micaceous, fine- and angular-grained	1, 900–1, 930
Silt, light-gray, micaceous	1, 975–2, 050
Clay, gray and white, silty, micaceous, carbonaceous	2, 143–2, 233
Sand, silty, micaceous, fine-grained, subangular	2, 233–2, 278
Sand, brownish-gray, silty, very fine grained, and lignite	2, 278–2, 279
Clay, hard, dark-gray, and white silt	2, 279
Sand, light-gray, silty, micaceous, carbonaceous, fine and very fine grained, subangular	2, 279–2, 280
Sandstone, light-gray, silty, micaceous, slightly carbonaceous, noncalcareous, fine-grained, subangular; at one place a few very small grains of glauconite	2, 280–2, 287
Clay, white, micaceous, carbonaceous, very finely sandy	2, 287–2, 288
Sand, thinly laminated, micaceous, carbonaceous, silty, clayey, very fine grained, and sandy clay	2, 288–2, 289
Sandstone, compact, glauconitic, highly micaceous, calcareous, fine-grained; bedding dips about 15° from plane normal to sides of core	2, 310–2, 311
Sandstone, light-gray, silty, micaceous, noncalcareous, very fine grained; thin seam of carbonaceous matter	2, 311–2, 313
Clay, dark-gray, silty, micaceous, very finely sandy; tubes and layers of light-gray micaceous sand	2, 313–2, 316

[1] The samples from 1,068 to 2,279 feet are cuttings.

Harris No. 1 well. Drilled by Louisiana Gas & Fuel Co.—Continued

	Depth at which sample was obtained (feet)
Wilcox formation—Continued	
Sand, thin-bedded, micaceous, clayey, with ½-inch interbedded layer of light-brown silty micaceous clay	2, 316–2, 317
Clay, dark-gray, silty, micaceous, very finely sandy; thin beds of white micaceous, silty very fine-grained sand	2, 317–2, 318
Clay, dark grayish-brown, highly micaceous, silty	2, 318–2, 319
Silt, light- and dark-gray, micaceous, clayey	2, 367–2, 368
Siltstone, gray, slightly micaceous, carbonaceous, clayey, calcareous	2, 368–2, 369
Silt, light-gray, slightly micaceous, clayey, noncalcareous	2, 369–2, 370
Clay, light and dark brownish-gray, silty, micaceous, carbonaceous, noncalcareous, very finely sandy	2, 370–2, 372
Clay, light-gray, micaceous, silty	2, 372–2, 373
Silt, light-gray, micaceous, alternating with layers of dark-gray clay	2, 374–2, 377
Clay, thinly laminated, light and dark brownish-gray, very finely micaceous, silty	2, 377–2, 279
Silt, light-gray, micaceous, carbonaceous, noncalcareous, very finely sandy, clayey, and alternating with layers of micaceous fine-grained sandstone and light-gray very calcareous clay	2, 379–2, 385
Clay, brown, carbonaceous, very micaceous, silty; pyrite	2, 386–2, 387
Silt, thin- and thick-bedded, light-gray, clayey, micaceous, and dark-gray silty clay; bedding dips about 30° from plane normal to side of core	2, 387–2, 388
Silt, light- and dark-gray, micaceous, noncalcareous, clayey	2, 388–2, 389
Clay, thinly laminated, dark-gray, silty, carbonaceous, micaceous, and light-gray clayey, micaceous silt; bedding dips about 25° from plane to normal side of core	2, 389–2, 391
Clay, crumpled, thin-bedded, dark-gray, carbonaceous, finely micaceous, silty	2, 391–2, 392
Clay, similar but slightly calcareous	2, 392–2, 393
Silt, massive, light-gray, micaceous, carbonaceous, noncalcareous clayey	2,396–2, 397
Silt, thinly laminated and cross-laminated, light- and dark-gray micaceous, carbonaceous clayey; bedding dips about 29° from plane normal to sides of core	2,397–2, 400
Porters Creek clay:	
Clay, dark-gray, with pockets of dark-gray calcareous, glauconitic, micaceous, fossiliferous clay	2, 400–2 ,401
Clay, dark-gray, micaceous, silty	2, 401–2, 402
Clay, black, calcareous, fossiliferous; pyrite	2, 438–2, 439
Clay, black, noncalcareous; no fossils	2, 439–2, 440
Clay, black, micaceous, noncalcareous, fossiliferous	2, 240–2, 441
Clay, black, slightly calcareous, fossiliferous	2, 443–2, 444
Clay, thinly laminated, noncalcareous; a little pyrite	2, 444-2, 452
Clay, thinly laminated, dark-gray to black	2, 460–2, 461
Clay, dark-gray to black, sparingly fossiliferous, slightly micaceous, slightly silty, noncalcareous; a little pyrite	2, 461–2, 473
Clay, laminated, medium-gray, slightly micaceous, noncalcareous, containing very small tubes filled with oxidized pyrite or marcasite	2, 473–2, 474

Harris No. 1 well. Drilled by Louisiana Gas & Fuel Co.—Continued

	Depth at which sample was obtained (feet)
Porters Creek clay—Continued	
Clay, dark-gray to black, noncalcareous; no fossils seen	2,474–2,477
Clay, compact, thinly bedded, black, noncalcareous, shaly	2,477–2,478
Clay, black, very slightly calcareous	2,479–2,481
Clay, dark-gray to black, fossiliferous. Miss Gardner reports *Nuculana saffordana?* (Harris). Henbest reports *Robulus midwayensis* (Plummer) fragments, and *Nodosaria affinis?* D'Orbigny fragments	2,482–2,486
Clay, dark-gray, hackly; pyrite; fragmentary fossils	2,486–2,488
Clay, dark-gray to black	2,488–2,489
Clay, dark-gray to black, hackly, fossiliferous; containing great concentration of finely disseminated marcasite in middle of core	2,489–2,490
Clay, compact, dark-gray, sparingly fossiliferous, hackly	2,490–2,494
Clay, dark-gray, hackly; containing an eighth-inch layer of hard impure limestone	2,494–2,495
Clay, compact, dark-gray, hackly, sparingly fossiliferous; pyrite	2,495–2,497
Clay, dark-gray, hackly, fossiliferous. Miss Gardner reports *Crassatellites gabbi* (Safford)? juv., *Nuculana saffordana?* (Harris), *Dentalium* sp. ind., *Cadulus?* sp. ind., indeterminate gastropod and indeterminate shell fragments. Henbest reports *Nodosaria* sp	2,497–2,500
Clay, compact, dark-gray, fossiliferous, slightly carbonaceous. Henbest reports: "The microfauna of this sample contains a number of species which are especially characteristic of the Texas Midway as described by Mrs. Plummer. Among the species are: *Robulus midwayensis* (Plummer), common in Midway, rare in Wilcox of Alabama. *Marginulina longiforma* (Plummer), upper Midway. *Marginulina subaculeata* var. *tuberculata* (Plummer), upper Midway of Texas and Alabama. *Siphonina prima* Plummer, Midway and Wilcox. The composition of the fauna as a whole is similar to that of the Texas Midway. The sample appears to be Midway and probably upper Midway."	2,500–2,504
Clay, soft, dark-gray, fossiliferous	2,504–2,506
Conglomerate of shell fragments in hard dark-gray, very fossiliferous clay	2,506–2,507
Clay, gray, very finely sandy, containing a mass of shell fragments. Henbest reports: "The sample contains a large number of variously shaped pellets, all having rounded edges, that are composed of lime; many or all of which are pieces of nullipore colonies."	2,510
Clayton formation:	
Limestone ("cap-rock"), gray, filled with fossil fragments, a few foraminifers and calcareous algae; some black clay filling interstices. Henbest reports: "These samples of the 'cap-rock' contain little in the way of diagnostic fossils. Several more or less incomplete specimens of *Robulus* cf. *midwayensis*	

Harris No. 1 well. Drilled by Louisiana Gas & Fuel Co.—Continued

	Depth at which sample was obtained (feet)
Clayton formation—Continued	
were found in the lower of the two samples. These and the associated specimens of *Robulus* appear to have a Paleocene aspect rather than Cretaceous, but, under the circumstances, I consider the evidence insecure. The rock appears to have originally been a coquina composed of irregular but small pieces of nullipore colonies. The edges of these small pellets are much rounded. Ordinarily such conditions would indicate extensive abrasive action of some sort."	2, 511–2, 512
Chalk. Henbest reports: "A mixture of white chalk and dark gray clay. The fossil assemblage contains a great number of *Siphonina* cf. *prima* and a few specimens of *Marginulina* cf. *longiforma*. Neither of these agrees closely enough with the species tentatively cited above as Midway forms nor to well-known and closely related species of the same genera in the Cretaceous for use as age indicators. The rest of the limited fauna gives little help. I cannot say definitely whether the sample is Cretaceous or Paleocene, but if I were to venture a guess my choice would be Paleocene."	2, 512–2, 513
Limestone, hard, fossiliferous	2, 513–2, 516
"Gas rock:"	
Calcium carbonate, containing a few dark grains of clayey limestone	2, 516–2, 552
Tuscaloosa (?) group:	
Clay, dark grayish-brown, carbonaceous, micaceous, noncalcareous, silty; some layers contain abundant finely disseminated iron pyrites	2, 907-2, 912
Clay, black, noncalcareous, with a few granules of white chalk, possibly from above; many small balls of brown calcareous clay	2, 912–2, 913
Clay, dark grayish-brown, micaceous, carbonaceous, silty, containing small, thin lenses of light-brown clay; a few small carbonized pyritiferous stems; some brown lenses effervesce slowly after long exposure to acid	2, 913–2, 915
Clay, medium and dark grayish-brown, silty, containing pyrite, carbonaceous matter, and a few granules of lime	2, 916–2, 917
Clay, brownish-gray, silty, containing carbonized and pyritized twigs, small calcareous pellets, and disseminated pyrite	2, 917–2, 929
Clay, dark brownish-gray, slightly micaceous, sparingly calcareous	2, 929–2, 931
Shale, compact, dark brownish-gray, slightly micaceous, sparingly calcareous, carbonaceous, containing large flakes of white and brown mica and considerable pyrite; bedding dips about 10° from plane normal to sides of core	2, 973–2, 975
Mud, greenish-gray and brown, calcareous, containing small pebbles of impure crystalline calcite and calcareous sandstone; some biotite and pyrite; resembles volcanic breccia	2, 975–2, 977
Mud, similar, calcareous, containing pyrite, biotite, and many rounded pebbles of calcareous sandstone, calcite, and green clay	2, 977–2, 984

Harris No. 1 well. Drilled by Louisiana Gas & Fuel Co.—Continued

	Depth at which sample was obtained (feet)
Tuscaloosa(?) group—Continued	
Igneous rock, greenish-gray and brown, composed of weathered fragmental material; big biotite crystals, feldspar, and igneous rock fragments of lamprophyre type. Park reports: "Biotite, orthoclase, and apatite in fragmental rock composed largely of carbonates. Some pleochroic chlorite. Some grains subrounded but most are angular. Some quartz fragments. Fragments of carbonatized igneous rock containing unaltered orthoclase. Sericite or talc(?). Some chalcedony. Cement is mostly calcareous and finely divided undetermined material. Some shreds of colorless mica, sericite. Little graphite(?). Many gas bubbles in the apatite."	2,984–2,991
Rock, similar, containing small veins of calcite up to a millimeter thick; many fragments of calcite, limestone, and calcareous sandstone; pyrite, biotite	2,991–2,994
Conglomerate of pebbles of dark-gray calcareous sandstone, calcite and igneous rock in a matrix of brown and greenish-gray sandy, calcareous clay; large biotite crystals; a volcanic breccia or a sedimentary deposit derived from nearby weathered volcanic rock	2,994–3,006
Conglomerate, similar, with crystals of calcite (dog tooth spar) and fluorite; vein of calcite cuts vertically through core	3,006–3,020
Breccia, hard, consisting of red material on one side of core and gray on the other; the surface between the two parts may be depositional or may be a fault. On one side of core is light-gray calcareous, clayey conglomerate containing pieces of calcite and of the red material; on the other side is a red calcareous clay containing large fragments of red sandstone, calcite, and siliceous material. Park reports: "Small amounts of biotite, orthoclase, and apatite in a highly altered clastic ground mass. Carbonates are well developed, and a large part of the ground mass is composed of a yellowish isotropic substance. Probably chloritic or serpentinous alteration material. Wide reaction(?) rims around most mineral grains. Some magnetite and sulphides are present. Some fragments contain small needles that resemble feldspar. There are apparently two types of rock, similar in composition and texture but one contains much more iron oxide." Other minerals include titanite, muscovite, quartz, and pyrite	3,017
Conglomerate, gray consisting of angular and rounded fragments of black calcareous sandstone, igneous rock, calcite, quartzite, and clay pellets in a matrix of very calcareous clay	3,018–3,020
Clay, compact, red, calcareous containing white lenses and pellets; similar to red part of core 3017 except that little fragmental rock is present; some small pebbles of quartzite and of calcite	3,020
Conglomerate, gray and brown, calcareous, containing pebbles of clay, sandstone, calcite, and soft igneous rock	3,020–3,025
Clay, similar to 3020–3025; underlain by conglomerate, highly weathered, containing large fragments of igneous rock, pyrite, and biotite; probably a volcanic breccia or tuff	3,025–3,036

Harris No. 1 well. Drilled by Louisiana Gas & Fuel Co.—Continued

	Depth at which sample was obtained (feet)
Tuscaloosa (?) group—Continued	
Clay, gray, silty, calcareous, containing small concretions, crystals and fragments of calcite and some other fragmental material. May be volcanic ash	3, 051–3, 053
Limestone, black, carbonaceous, very finely granular, crystalline; vertical slickensides on interior of core suggest faulting; side is highly polished by the drill; limestone is highly magnetic; when dissolved in acid the 10± percent residue consists of very fine-grained magnetite powder	3, 053–3, 055
Clay, gray and white, very calcareous; a few grains of quartz and mica	3, 055
Clay, gray and white, laminated, lenticular, very calcareous. Park reports: "Thin banded white and gray fine-grained rock. Some of the white material is in thin, small lenses. Looks more like an altered lava than a sediment."	3, 055–3, 060
Clay, hard, gray, noncalcareous, containing a little carbonaceous matter and one piece of crystalline limestone; underlain by volcanic breccia like above containing a secondary mass of white crystalline limestone; pebbles are angular	3, 078–3, 092
Igneous material, fragmental, greenish gray; large biotite crystals and much pink secondary calcite. Park reports: "Resembles an altered perlitic tuff."	3, 126–3, 149
Silt, blue-gray, calcareous, containing well-rounded pebbles; broken pebbles show long needles of apatite. These pebbles range in size from 15 x 11 x 10 mm to less than 1 mm; they are of volcanic ash. Park reports that some of the pebbles have preserved apparent flow structure	3, 149–3, 153
Conglomerate of impure limestone, igneous rock, and volcanic ash in a matrix of gray calcareous silt; one part of core contains much secondary crystalline calcite, some of which is transparent and some white and opaque	3, 153–3, 157
Conglomerate, compact, blue-gray and tan, silty, calcareous, containing crystals of biotite, large angular fragments of calcite and many of small well rounded volcanic ash composed of devitrified volcanic glass; much of matrix is bluish green	3, 157–3, 179
Agglomerate of igneous material containing many coarsely crystalline, sharply angular fragments of calcite, many of which contain apatite; phenocrysts of fine-grained biotite, apatite, orthoclase, and melanite garnet in a very fine groundmass, some of which is vesicular. One large red pebble of igneous rock surrounded by a band of pyrite	3, 197
Tuffaceous material containing calcite, angular fragments of limestone, igneous rock, volcanic ash, and crystals of biotite	3, 200–3, 215
Agglomerate, hard, blue-green, volcanic; contains a large angular pebble 33 mm long, of very calcareous magnetite sandstone that has a thin coating of green clay on surface; this material resembles core of magnetite limestone taken at depths of 3053 to 3055 feet	3, 220–3, 227

Harris No. 1 well. Drilled by Louisiana Gas & Fuel Co.—Continued

	Depth at which sample was obtained (feet)
Tuscaloosa(?) group—Continued	
Limestone, black, slightly magnetic; cut by veins of white calcite; pyrite; underlain by highly-altered igneous material; calcite, igneous rock fragments, and ashes(?) in a blue-green matrix	3, 227–3, 232
Calcareous rock, dark-gray, fragments, containing many pieces of green igneous rock; underlain by dark-gray magnetic limestone, containing many inclusions of crystals of calcite that may be secondary; biotite; underlain by fragmentary core consisting of pieces of calcite, dark-gray laminated silty clay with very small lenses of light-brown silty clay and gray clay filled with fragments of rock	3, 232–3, 239

Lower part of Wm. S. Hamilton and others, No. 1 well. Drilled by Gulf Refining Co. of Louisiana

[1320 feet east and 1320 feet north 6°30′ east from southwest corner sec. 4, T. 5, N., R. 2 E., Rankin County; altitude, 285 feet]

	Depth at which sample was obtained (feet)
Porters Creek clay:	
Clay, gray, sandy, fossils, pyrite	2, 555–2, 560
Clayton formation:	
Limestone, hard, gray, containing some calcite veins and calcareous algae	2, 560–2, 566
"Gas rock:"	
Limestone, hard, porous, containing abundant veins of calcite, impressions of shells, and calcareous algae	2, 572–2, 580
Limestone, less porous, semicrystalline, containing algae	2, 600–2, 613
Limestone, hard, cream-colored, semicrystalline	2, 613–2, 625
Limestone, hard, cream-colored, semicrystalline, containing impressions of pelecypods	2, 625–2, 640
Chalk, compact, white, containing veins of calcite and impressions of pelecypods	2, 640–2, 648
Chalk, porous, very white, containing cavities from which fossils were dissolved; composed of an aggregate of very fine calcite crystals, almost pure $CaCO_3$, no clay, and a very few other minerals	2, 648–2, 667
Limestone, compact, white, somewhat porous; cavities lined with calcite crystals; impressions of fossils	2, 705–2, 718
Silt, very soft, composed of pure $CaCO_3$; entire sample dissolves in dilute HCl with no noticeable residue	2, 737–2, 756
Chalk, porous, white, completely impregnated with calcite making a compact rock; apparently pure $CaCO_3$; many cavities that are the impressions of fossil shells, especially gastropods; some of cavities lined with crystals of calcite	2, 775–2, 797
Limestone, very light cream-colored, containing much powdery limestone and many calcite veins; not so porous as overlying beds	2, 828–2, 846
Like preceding core; polished section shows many corals; very pure $CaCO_3$; *Heliopora* sp. (coral) and bryozoa identified by Bassler and Ulrich	2, 865–2, 878

Lower part of Wm. S. Hamilton and others, No. 1 well. Drilled by Gulf Refining Co. of Louisiana—Continued

	Depth at which sample was obtained (feet)
"Gas rock"—Continued	
Limestone, similar to above. Calcite impregnation nearly complete	2,878–2,898
Calcium carbonate, very pure, made up of tight, interlocking calcite with cavities filled with soft chalky pure $CaCO_3$; soft material is remains of fossils, mostly corals	2,898–2,918
Limestone, compact, very white, very finely crystalline, very pure, no fossils seen	2,918–2,937
Limestone, compact, white, very finely crystalline, pure, containing calcite veins and a few chalky fossils	2,937–2,955
Limestone, compact, light grayish-tan, crystalline, impermeable, containing a very few chalky fossil impressions, a little very fine pale glauconite, and a few grains of sand; residue insoluble in HCl consists predominantly of quartz silt with a few grains of glauconite and feldspar (microcline?). Miser reports: "Clear-water limestone perhaps deposited near an island of older rocks. Bryozoans and corals are of such types as to indicate that limestone is of Cretaceous age."	2,965–2,973
Limestone, very pure, crystalline, like 2918–2937; a little residue (insoluble in HCl) consists of quartz silt and a few grains of feldspar and glauconite; much less residue than 2965–2973	2,973–2,992
Tuscaloosa(?) group or Cotton Valley(?) formation:	
Clay, light-gray, noncalcareous, finely micaceous, very slightly silty	2,992–3,003
Clay, brownish-red, silty, micaceous, with greenish-gray lenses; slightly calcareous; red color may be secondary	3,003–3,010
Clay, brownish-red, silty, micaceous, thin-bedded; slightly salty	3,010–3,016
Clay, light brownish-red, finely laminated, silty, slightly sandy. Park reports: "Red material containing fine grains of quartz, some sericite and carbonates. Some of the grains are angular but most are subrounded."	3,024–3,030
Clay, dark reddish-brown, silty, containing greenish-gray lenses of silty clay	3,030–3,040
Sandstone, very light-brown, very porous, loosely cemented; made up almost entirely of fine to medium quartz grains; a few white grains that appear to be silt aggregates; a calcareous vein, 1 mm thick, cuts core vertically	3,040–3,049
Siltstone, soft, white, fine, sandy, and brownish-red clay which is slightly salty	3,049–3,087
Sand, angular, medium-grained, mostly quartz, loosely cemented by greenish-gray silty clay; some pyrite and a very little mica	3,087–3,105
Silt, dark, brownish-red, highly micaceous, clayey; slightly salty	3,105–3,121
Sandstone, white, noncalcareous, highly porous, fine- to medium-grained quartz; cut by narrow noncalcareous white veins	3,121–3,140

Lower part of Wm. S. Hamilton and others, No. 1 well. Drilled by Gulf Refining Co. of Louisiana—Continued

	Depth at which sample was obtained (feet)
Tuscaloosa(?) group or Cotton Valley(?) formation—Con.	
Sandstone, similar material containing a few more white silt grains; the veins are darker and greenish suggesting hydrothermal activity	3,140–3,159
Clay, light-gray and dark brownish-red, mottled, slightly silty, finely micaceous, hard, several small cylindrical rods, 1 to 2 mm in diameter, suggest filled worm borings	3,159–3,180
Clay, thinly laminated, medium brownish-red, calcareous, finely micaceous, silty, salty	3,180–3,200
Sandstone, white, porous, noncalcareous, angular-grained, fine- to medium-grained, containing a few grains of chlorite(?)	3,200–3,219
Cotton Valley(?) formation:	
Sandstone, light-salmon, tightly-cemented, calcareous, angular-grained, fine- to medium-grained. Ross reports: "Specimen composed of angular quartz grains and a little feldspar; contains much interstitial calcite, part of which appears to have replaced quartz and may be secondary."	3,219–3,232
Clay, dark reddish-brown, flaky, highly micaceous, silty; not salty	3,232–3,249
Clay, dark reddish-brown, massive, micaceous, silty, containing medium grains of angular quartz and some calcite; not salty	3,249–3,268
Igneous rock, soft, altered, light greenish-gray, felsitic	3,268–3,309
Igneous rock, altered, and conglomerate of granules of red silty clay in a greenish-gray silty clay matrix. Ross reports: "The red pebbles are composed of iron oxide and calcite possibly derived from the alteration of ferruginous carbonate. The groundmass is composed of angular quartz grains imbedded in calcite."	3,309–3,328
Sandstone, light-gray, thin-bedded, calcareous, micaceous, fine-grained; and thin-bedded red and gray calcareous, micaceous, silty fine-grained sandstone. Ross reports: The sandstone "is made up of fine-grained angular quartz, clay material, and and much mica. It seems to have been little changed by any proximity to an igneous rock."	3,328–3,342
Claystone, dark reddish-brown, somewhat flaky, micaceous, silty, neither calcareous nor salty; part of one core is slickensided	3,342–3,376
Igneous rock, light-green, highly altered	3,376–3,399
Sand, micaceous, white, very fine; in matrix of white clay	3,399–3,418
Sandstone, fine, very angular-grained, containing many grains of pyrite; cut by many thin dark veinlets or shear zones that appear to contain a concentration of magnetite and sulphide; many of the quartz grains are euhedral, probably because of secondary growth	3,418–3,430
Sandstone, similar, containing a number of somewhat spherical shells of quartz grains coated by magnetite surrounding cores of euhedral quartz grains containing less coating; shells	

Lower part of Wm. S. Hamilton and others, No. 1 well. Drilled by Gulf Refining Co. of Louisiana—Continued

	Depth at which sample was obtained (feet)
Cotton Valley (?) formation—Continued	
have diameters up to 1.5 cm; sandstone is white except for shells, and is cut by zones in which the quartz has been profoundly granulated and which appear to be shear zones; the numerous calcite veins seem to have been introduced along shear zones; one piece of green igneous rock altered to green clay	3,430.5–3,432
Sandstone, compact, hard, containing small euhedral quartz grains in white silty clay matrix; cut by white and dark-gray shear zones	3,432–3,433
Igneous rock, light- and dark-gray, altered, cut by white slickensided veins. Ross reports: "The bluish-gray igneous rocks vary slightly in texture and possibly somewhat in original composition but are essentially similar. The dominant mineral is plagioclase with lesser amounts of ferromagnesian minerals. These seem to be largely augite but there is some evidence of olivine in one or two sections. Thus the rock seems to have about the composition of diabase or andesite. The minerals are now completely altered—the feldspar to a clay-like mineral resembling halloysite and the ferromagnesian minerals to clay and iron oxides. Much calcite has been introduced during this alteration. Specimen 3,488–3,492 is the only one showing essential differences. Part of the specimen is similar to that described above, but the remainder is almost pure plagioclase feldspar."	3,488–3,492
Igneous rock, dark-green, altered; and thinly laminated, light and dark-gray, tightly cemented, calcareous, very fine grained sandstone cut vertically by very thin veinlets of calcite; bedding in core dips 20°, Ross reports: "This is a banded sandstone. The grains are angular and dominantly quartz, but feldspar and mica are also present. The banding is partly due to zones that are richer in calcite, part [of which] appears to be secondary. The specimen contains disseminated pyrite, some [of which] in concentrated in veins of secondary calcite. There is, therefore, evidence of mineralization of the sandstone by the igneous rock."	3,492–3,511
Clay, soft, gray, very salty; and white very calcareous, very fine sandy clay	3,511–3,515
Sandstone, dark-gray, thinly laminated, slightly micaceous, fine-grained; on some bedding planes and on a shear, cutting the core at an angle of 40° to the bedding, there is a concentration of mica and black organic(?) matter; the sand grains are angular, but euhedral grains are not conspicuous	3,515–3,520
Sandstone, light-gray, tightly cemented, noncalcareous, highly micaceous, containing thin seams of carbonaceous sand and a few tiny lenses of coal	3,520–3,528
Siltstone, reddish-brown, hard, very finely micaceous; cut by a small calcareous veinlet; contains small lenses of white calcareous siltstone or very fine-grained sandstone	3,528–3,536

Lower part of Wm. S. Hamilton and others, No. 1 well. Drilled by Gulf Refining Co. of Louisiana—Continued

	Depth at which sample was obtained (feet)
Cotton Valley (?) formation—Continued	
Siltstone or silty shale, hard, light-brown, thinly laminated, finely micaceous; some layers slightly calcareous; bedding dips about 25°; bedding planes contain minute bits of carbonaceous matter	3,536–3,545
Sandstone, finely cross-bedded, light-gray, very slightly calcareous, salty, micaceous, silty, very fine grained; bedding dips about 25°; concentration of mica flakes and carbonaceous matter on bedding surface	3,545–3,550
Sandstone, compact, white, slightly micaceous, noncalcareous, very fine grained, containing many elongate grains of carbonaceous matter	3,550–3,558
Sandstone, similar, containing more mica	3,558–3,573
Sandstone, massive, white, angular-grained, fine-grained and very fine grained, noncalcareous, containing less mica and less carbonaceous matter than overlying core	3,573–3,592
Sandstone, similar to preceding; a little disseminated pyrite	3,592–3,606
Shale, dark-gray, slightly carbonaceous, slightly calcareous and magnesian, very thin bedded	3,606–3,623
Siltstone, medium brownish-red, very finely sandy and micaceous, clayey, noncalcareous, slighty salty	3,623–3,642
Sandstone, medium reddish-brown, silty, micaceous, slightly carbonaceous, thinly laminated; calcareous along bedding planes	3,642–3,655
Silt, thin-bedded, reddish-brown; calcareous micaceous, silty very fine grained sandstone; and gray calcareous siltstone; finely cross-bedded; one side of core is slickensided and may represent a fault	3,655–3,673
Siltstone, massive, light reddish-brown, micaceous, carbonaceous, noncalcareous, clayey, and very finely sandy; part of core is thinly laminated; salty along bedding planes	3,673–3,687
Shale, thinly laminated, in part massive, gray finely micaceous, slightly calcareous, silty, sparingly carbonaceous	3,687–3,706
Sandstone, white, very porous, fine-grained to very fine grained, containing a few calcite grains, widely scattered grains of tourmaline, and a little muscovite	3,706–3,718
Conglomerate or breccia made up of subrounded to angular pebbles of tan limestone in a calcite matrix; some pyrite and considerable vein calcite	3,718–3,720
Sandstone, massive, light-gray, silty, micaceous, very slightly calcareous, slightly glauconitic, salty very fine grained, containing small bodies of reddish-brown sandstone; a little disseminated pyrite. Apparently gray sandstone is leached or reduced from red	3,756–3,775
Sand, massive, white, very porous, noncalcareous, micaceous, containing a few grains of pink quartz and some dark brown grains of tourmaline	3,775–3,790

Lower part of Wm. S. Hamilton and others, No. 1 well. Drilled by Gulf Refining Co. of Louisiana—Continued

	Depth at which sample was obtained (feet)
Cotton Valley(?) formation—Continued	
Sandstone, massive, white, porous, loosely cemented, noncalcareous, slightly micaceous, fine-grained	3,790–3,809
Sandstone, similar, containing many scattered grains of tourmaline; light reddish-brown clay has penetrated the core in places, probably from the drilling mud	3,809–3,824
Sandstone, massive, light reddish-brown, micaceous, silty, slightly calcareous, salty, fine-grained	3,824–3,836
Siltstone, cross-bedded, dark reddish-brown, slightly salty, micaceous, clayey, very finely sandy	3,850–3,869
Sandstone, thinly laminated, light-gray, highly micaceous, silty, salty, noncalcareous, very fine grained	3,869–3,872
Claystone, medium-gray, noncalcareous, stained with red in widely scattered small stringers; not salty; slickensided	3,872–3,891
Clay, thin-bedded, medium-gray, slightly micaceous, calcareous, slightly indurated	3,901–3,920
Clay, mottled, rusty-brown and medium-gray, micaceous, calcareous, slightly indurated	3,920–3,938
Sandstone, thinly cross-bedded, light-gray, slightly calcareous, very fine grained, with a concentration of muscovite and carbonaceous matter along the bedding planes; bedding dips 25°	3,938–3,959
Sandstone, massive, mottled, medium reddish-brown and white, silty, micaceous, salty, calcareous, very fine grained	3,959–3,976
Sandstone, massive, white, very calcareous, fine-grained, containing concentrations of muscovite and carbonaceous matter along some planes (bedding planes?)	3,976–3,985
Limestone, medium-gray, silty, micaceous, clayey	3,994–3,999
Clay-shale, very compact, black, calcareous, with small, thin patches of iron pyrites on bedding planes; sandstone, light pinkish-gray, laminated, fine, with great concentration of muscovite and carbonaceous matter on bedding planes; sandstone, very tightly cemented, massive, light-gray, slightly calcareous, micaceous, containing many small inclusions of greenish clay	4,009–4,012
Tinguaite. Very hard, dark-greenish, crystalline igneous rock with many small spots of pinkish feldspar and small shiny needles. Ross reports: "The rock is composed of the following minerals: sodic plagioclase, nephelite, analcite, aegerite, augite, and a little melanite garnet. The habit is that of an intrusive rock. The sodic character and the minerals that have developed suggest that it is related to the rocks of Arkansas."	4,024–4,025

Lower part of Rainey No. 1 well. Drilled by Gulf Refining Co. of Louisiana

[760 feet south and 150 feet east of the northwest corner of sec. 13, T. 5 N., R. 1 E., Rankin County; altitude, 268 feet]

	Depth at which sample was obtained (feet)
Porters Creek clay:	
Clay, dark-gray, compact, very finely micaceous, shaly; contains pyrite	2,403–2,412
Clay, dark-gray to black, noncalcareous, in part thin-bedded; hard bed of silty siderite	2,446–2,455
Clay, black, thin-bedded, very finely micaceous, slightly calcareous in places	2,455–2,473
Clay, dark-gray, noncalcareous, containing thin, discontinuous veins of pyrite	2,473–2,491
Clay, dark-gray, thinly laminated, containing many fossil shells and fragments	2,491–2,500
Clayton formation:	
Limestone, dark-gray and white, filled with shell fragments and algal remains	2,501–2,511
"Gas rock:"	
Limestone, white, crystalline, chalky, cut by calcite veins	2,510–2,520
Limestone, hard, cream-colored and white, granular, chalky	2,520–2,538
Calcium carbonate, very soft, pure; resembles commercial precipitated chalk	2,733–2,742
Chalk, somewhat compact, white, like above	2,799–2,808
Limestone, hard, white, chalky, containing algal remains, echinoderm plates(?), foraminifers(?), and veins of calcite	2,836–2,837
Tuscaloosa (?) group:	
Sandstone, tightly cemented, white, slightly calcareous, fine-grained; underlain by greenish-gray calcareous silty clay and chalk (mostly drilling mud?); underlain by brownish-gray carbonaceous, silty, micaceous thin-bedded clay	2,847–2,850
Clay, light, grayish-brown, silty, micaceous, very slightly calcareous, containing grains of carbonaceous matter, a few small siliceous pebbles, and a little biotite	2,850–2,859
Clay, like preceding, and fine-grained brownish-gray slightly calcareous sandstone containing small pebbles of quartz and fragments of igneous rocks(?)	2,859–2,868
Clay, medium brownish-gray, silty, micaceous, noncalcareous, and fine-grained quartzitic sandstone; pyrite in thin layers	2,868–2,877
Sandstone, light tan, fine-grained, calcareous, containing large plates of biotite and many small lenses, layers, and grains of carbonaceous matter and a few granules and small pebbles of quartz	2,877–2,885
Silt, medium gray, micaceous, clayey, containing many small lenses, layers, and grains of carbonaceous matter and a few granules and small pebbles of quartz	2,885–2,894
Sandstone, fine-grained, noncalcareous, quartzitic	2,894–2,902
Silt, tan, very calcareous, clayey, containing a few quartz granules and some very fine grained sand	2,902–2,912
Clay, medium grayish-brown, carbonaceous, silty, noncalcareous, dipping 20°, and white quartzitic sandstone	2,912–2,918

268680—53——4

Lower part of Rainey No. 1 well. Drilled by Gulf Refining Co. of Louisiana—Continued

	Depth at which sample was obtained (feet)
Tuscaloosa (?) group—Continued	
Clay, medium gray, noncalcareous, silty, containing flattened carbonized plant fragments and a few small quartz granules; contains a lens of white fine-grained noncalcareous sand loosely cemented by white clay; bedding dips 30°	2, 918–2, 927
Clay, medium-brown, silty, carbonaceous, containing large flakes of biotite; interbedded with fine sand in a noncalcareous white matrix; part of core contains a thin seam of lignite; bedding dips about 25°	2, 927–2, 936
Igneous rock, coarsely crystalline, light brownish-gray, made up almost entirely of interlocking feldspar crystals. C. S. Ross reports: "An igneous rock of the syenitic aplite type composed dominantly of orthoclase but containing a little albite and quartz."	2, 936–2, 940
A mixture of fragments of light gray, noncalcareous, silty clay, fine-grained noncalcareous quartzite, and dried drilling mud	2, 936–2, 945
Clay, thinly laminated, dark-brown, silty, carbonaceous, containing flakes of biotite; bedding nearly horizontal	2, 948–2, 952
Quartzite fragments in a matrix of greenish-gray silty clay that contains large biotite flakes	2, 952–2, 962
Clay, light-gray, slightly calcareous, containing biotite flakes and small rounded and subrounded pebbles; may have originally been tuffaceous	2, 962–2, 971
Silt, greenish-gray, medium-grained, calcareous, sandy	2, 971–2, 979
Sand, light-gray and red, silty, coarse, cemented by light-gray silt; large biotite flakes; probably tuff. Ross reports: "In part igneous fine-grained explosive type of rock"	2, 979–2, 988
Igneous rock (Tuscaloosa? age):	
Igneous rock, green, altered. Charles Park reports: "The rounded grains suggest sedimentary material and the rock may possibly be a tuffaceous sediment, but is more likely igneous. Owing to quantities of fine alteration products the mineral species are almost impossible to identify."	2, 988–2, 996
Igneous rock, altered, like that from 3,021–3,035	2, 996–3, 011
Igneous rock, dark-green. Ross reports: "Highly altered igneous rock of peridotite type similar to 3,021–3,035. Contains some fresh biotite, but is largely chloritic alteration products of augite."	3, 011–3,021
Igneous rock, green. Ross reports: "A peridotite composed of about two-thirds augite, 20 percent biotite, and magnetite, ilmenite, titanite, and apatite as abundant accessories. A little pyrite is present. The augite and ilmenite are slightly altered but the rock is unusually fresh for one of the peridotite type."	3, 021–3, 035
Igneous rock, similar to 3,021–3,035	3, 035–3, 051
Igneous rock, dirty green, altered, similar to 3,135–3,137	3, 051–3, 083

Lower part of Rainey No. 1 well. Drilled by Gulf Refining Co. of Louisiana—Continued

	Depth at which sample was obtained (feet)
Igneous rock (Tuscaloosa? age)—Continued	
"Green igneous rock with large crystals of biotite cut by veinlets of carbonates and sulfides" (Park). Ross reports: "Highly altered potash-rich lamprophyre, contains abundant biotite and smaller amounts of apatite which is unusually abundant, partly altered augite, magnetite, and orthoclase. Probably contained plagioclase which is now represented by a sericitic aggregate. Small amounts of secondary calcite now present."	3, 135–3, 137
Igneous rock. Ross reports: "Similar to 3135–3137. Contains abundant orthoclase and smaller amounts of magnetite, biotite, and titanite. Plagioclase and augite, if originally present, are now completely altered. Rock now dominantly calcite."	3, 160–3, 167
Igneous rock, greenish-gray, medium-grained, cut by numerous veinlets of carbonates and sulphides	3, 279–3, 282
Igneous rock, hard, brittle, light bluish-tan. Ross reports: "Highly altered porphyritic rock with fine-grained groundmass. Probably represents a very fine-grained rock of the lamprophyre type. Phenocrysts are biotite, plagioclase, altered hornblende. Groundmass appears to have been composed of plagioclase, biotite, and hornblende or augite."	3, 334–3, 340
Igneous rock, medium soft to hard, grayish-green, with white spots. Ross reports same as 3,334–3,340	3, 380–3, 388
Igneous rock, coarse-grained, containing large biotite crystals	3, 479–3, 482
Igneous rock, highly altered, light-gray, resembles core from 3,334–3,340	3, 497–3, 500
Igneous rock, fine-grained, greenish-blue	3, 538–3, 545
Igneous rock, light-gray very soft, highly slickensided. Park suggests a sheared and altered igneous rock	3, 545–3,554
Igneous rock. Ross reports: "The specimen is composed largely of calcite and plagioclase. It is not possible to determine whether the specimen represents clastic igneous material in limestone or an igneous rock that has been very thoroughly replaced by calcite."	3, 596–3,600
Igneous rock. Ross and Park state that core is of granitoid and feldspathic porphyritic rock rather completely replaced by calcite, but containing a little fresh orthoclase and much sericitized plagioclase. Similar to 3,604–3,607	3, 600–3, 604
Igneous rock. Park reports: "Fresh black granitoid rock in hand specimen. One [fragment of] core shows what may be a shale or fine glassy wall rock." Ross reports: "A very coarse-grained igneous rock of the lamprophyre type. The minerals in the order of their abundance are as follows: augite, sericitic aggregate (probably plagioclase originally), biotite, titanite, magnetite, hornblende (brown), apatite. The minerals are all fresh except the sericitized plagioclase. The rock is unusual in that titanite is one of the major minerals and makes up 20 percent of the rock. The accessory minerals—magnetite and apatite—are also abundant. Hornblende is sparse."	3, 604–3, 607

Samples from the Hanna No. A–1 well. Drilled by the Gulf Refining Co. of Louisiana

[212 feet south and 262 feet east of the center of sec. 23, T. 5 N., R. 1 E., Rankin County; altitude 265 feet]

	Depth at which sample was obtained (feet)
Sandstone, compact, light-gray, noncalcareous, containing carbonaceous matter	3,019–3,023
Conglomerate, hard, made up of red, green, light-brown, and tan pebbles in a red and light-blue matrix; some of pebbles are calcareous	3,060–3,065
Shale, very hard, red and bluish-gray, micaceous, noncalcareous, sandy; shale is slickensided along vertical shear	3,065
Igneous rock, hard, green, calcareous. Ross reports: "The specimen is rather highly altered and it is not possible to determine the exact character of the original rock. It seems to have been a highly alkalic rock with a groundmass of spray-like, feldspar crystals. A few phenocrysts were present but are now entirely altered to an almost amorphous aggregate. These appear to have been hornblende, and titanite was probably also present. Numerous crystals of magnetite are present and small aggregates of secondary pyrite."	3,070–3,074
Sandstone, hard, gray, calcareous, containing balls and lenses of black micaceous clay. Part of the core consists of two parts cut by a high-angle fault(?) with slickensides; one part consists of white, calcareous sand containing a rounded pebble of red sandstone, 1 inch in diameter, the other part consists of white, calcareous sandstone containing pellets of black clay. Milton reports: "The sample is a gray, calcareous sandstone. It contains a pebble of sandstone about 1 inch across. The pebble consists of equidimensional, subrounded grains of quartz fitted into a close mosaic with the interstitial material, originally clayey, now completely recrystallized to a micaceous aggregate. Numerous well rounded zircons are present. The matrix of the pebble consists of angular, fairly coarse, quartz grains cemented by crystallized carbonate. There are also rounded masses of finely crystallized carbonate."	3,165–3,169
Sandstone, hard, very dark-red, micaceous, with green streaks; green, sandy conglomerate, containing some calcareous pebbles	3,264–3,266
Sandstone, very hard, dark-red, very steep fracture in core; another part of core consists of very hard, mottled bluish-gray, and dark-red sandstone	3,384–3,400

Lower part of Misterfeldt No. 1 well. Drilled by Lion Oil & Refining Co.

[620 feet east and 80 feet south of the northwest corner SW¼NE¼ sec. 2, T. 4 N., R. 1 E., Rankin County, altitude, 275 feet. Descriptions by R. D. Norton of cores and cuttings to a depth of 3,491 feet, are published in U. S. Geological Survey Bull. 831–A, pp. 5, 6, 1932]

	Depth at which sample was obtained (feet)
"Gas rock:"	
Limestone, hard, white, containing a small amount of pyrite and some secondary calcite. This is the core from which Vaughan and Cole obtained the genotype of *Lepidorbitoides* (*Asterorbis*) *rooki* described in Nat. Acad. Sci. Proc., vol. 18, pp. 611–613, pl. 1, figs. 1–6, 1932. They also recognized *Hamulus* sp	3, 480–3, 491
Tuscaloosa(?) group:	
Clay, laminated, red and white, noncalcareous, silty. Bit sample	3, 502–3, 505
Sandstone, white, porous, friable, micaceous, noncalcareous, quartzose, subrounded, medium-grained. Driller reported 20 fourbles of salt water and a slight show of gas	3, 515–3, 519
Sandstone, gray, medium-grained, slightly more compact than overlying core	3, 546–3, 551
Sandstone, compact, light-gray, silty, noncalcareous, slightly micaceous	3, 567–3, 573
Sandstone, light-gray, silty, micaceous, carbonaceous, fine-grained	3, 595–3, 596
Sandstone, compact, greenish-gray, noncalcareous, very fine grained	3, 628–3, 634
Shale, thin-bedded, flaky, red, silty containing a few thin layers of white silt. Bit sample	3, 673–3, 675
Clay, carbonaceous, silty	3, 770–3, 775
Clay, carbonaceous, micaceous, fine-grained, sandy, contains a few fragments of pelecypods	3, 787–3, 791
Sandstone, dark greenish-gray, micaceous, fine-grained	3, 804–3, 807
Sandstone, gray, calcareous, micaceous, very fine grained	3, 827–3, 833
Clay, less compact, dark-gray, silty, micaceous, noncalcareous	3, 842–3, 846
Sandstone, gray, laminated, calcareous, very micaceous, fine-grained	3, 850–3, 860
Sandstone, similar to preceding core, but more massive	3, 911–3, 913
Sandstone, angular, very calcareous, cemented by green silt. Ross reports: "Chloritic material derived from igneous rock; big biotite crystals, a little igneous matrix, orthoclase crystal." Underlain by sandstone, compact calcareous, with grains of glauconite and green and black igneous rock. Ross reports: "Microcline and fine-grained volcanic rock."	3, 940–3, 948
Claystone, red, micaceous, sandy, silty	3, 990–3, 996
Claystone, darker-red, silty, micaceous	4, 004–4, 010
Sandstone, white, very porous, silty	4, 032–4, 034
Sandstone, thin-bedded, white, very micaceous, noncalcareous	4, 069–4, 075

EXPOSED ROCKS

ROCKS OF TERTIARY AGE

EOCENE SERIES

CLAIBORNE GROUP

COCKFIELD FORMATION

The Cockfield formation was formerly called the Yegua formation in Mississippi, but in 1927, as a result of a field study of the type locality by Miss Gardner (1927, pp. 245–251), the name Yegua was abandoned by the Geological Survey and the name Cockfield formation substituted. The Cockfield was originally named by Vaughan (1895, p. 220) for lignitiferous sands and clays in Louisiana that rest conformably on the fossiliferous lower part of the Claiborne group at St. Maurice and underlie the Jackson at Montgomery. Vaughan named this formation "Cocksfield Ferry beds" but A. C. Veatch (1906, pp. 37, 38) pointed out that the name of the ferry is "Cockfield" and renamed the formation Cockfield. Mellen (1940, p. 13) considered the Yegua (Cockfield) the upper member of the Lisbon formation, mainly because he could detect no disconformity between the Yegua and the Lisbon.

Areal distribution.—The Cockfield formation crops out in a belt that trends S. 60° E. from Holmes and Carroll Counties in the west to Clarke County in the east. The width of the belt narrows toward the east.

Within the Jackson area the Cockfield formation crops out at many places in creek beds in the northern part of the city of Jackson and immediately northeast of the city limits, secs. 25, 26, 35, and 36, T. 6 N., R. 1 E., Hinds and Rankin Counties. (See geologic map, pl. 1.)

Lithologic character.—The Cockfield formation consists predominantly of fine and very fine micaceous, locally carbonaceous, red, pink, yellow, cream, and white sand and of varyingly carbonaceous sandy clay and thin beds of impure lignite. The bedding is commonly thinly laminated or crossbedded, but massive beds of sand have been seen at a few places.

One of the best exposures of the formation near Jackson is in a gully on the south (right) side of Crane Creek in the SW¼SW¼SW¼ sec. 25, T. 6 N., R. 1 E., where the following section is exposed:

Section on the northward-facing slope of the valley of Crane Creek

	Ft	in
Concealed by soil to top of the hill	45	0
Moodys Branch formation: Sand, highly clayey, fossiliferous, glauconitic	25	0
Concealed by colluvium	3	0
Cockfield formation:		
Sand, crossbedded, tan and gray, fine; alternating with lignitic layers; to top of dry waterfall	7	8
Sand, laminated, dark-brown, carbonaceous		2
Sand, laminated, light-gray and tan, fine	3	2
Sand, massive and crossbedded, blue-gray, containing comminuted plant remains grading downward into sandy clay underlain by massive fine lignitic sand	18	0
	102	0

Thickness.—Records of wells drilled near Jackson show that the Cockfield formation is about 220 to 250 feet thick, but it is believed to thicken toward the south. Only the upper 30 feet is exposed near Jackson.

Fossil content.—Berry (1924, pp. 1–92) has studied the fossil plants from the Cockfield formation of Louisiana, Arkansas, and Texas, but has not made a careful study of those in Mississippi. A collection from a cut in the Gulf, Mobile & Ohio Railroad, NE¼SE¼ sec. 35, T. 6 N., R. 1 E., Hinds County, (fig. 2) just southwest of the Jackson water works, was sent him in 1930 and he stated that the plants obviously were of Cockfield age, but made no specific determinations, merely stating that many of the specimens were very good. Berry records 66 species from the Cockfield, but it is not known how many of these occur in Mississippi.

Stratigraphic relations.—The Cockfield formation is overlain disconformably by the Moodys Branch formation of the Jackson group. The disconformity is characterized by small fragments of clay reworked into the base of the Moodys Branch forming a basal conglomerate, by sharp change in lithology at the contact, by borings that were made by marine animals in the Cockfield and filled with glauconitic sand of the overlying Moodys Branch, and by a discordance in dip between the Cockfield and Moodys Branch. The discordance in dip is partly due to cross bedding in the Cockfield.

The disconformity is well exposed at the type locality of the Moodys Branch formation on Moodys Branch a few yards southeast of the corner of Poplar Boulevard and Peachtree Street, Jackson (SW¼ SW¼ sec. 35, T. 6 N., R. 1 E.), and in the cut of the Gulf, Mobile & Ohio Railroad a hundred yards southwest of the Jackson waterworks (NE¼SE¼ sec. 35, T. 6 N., R. 1 E.). In this cut (fig. 2) the base of the

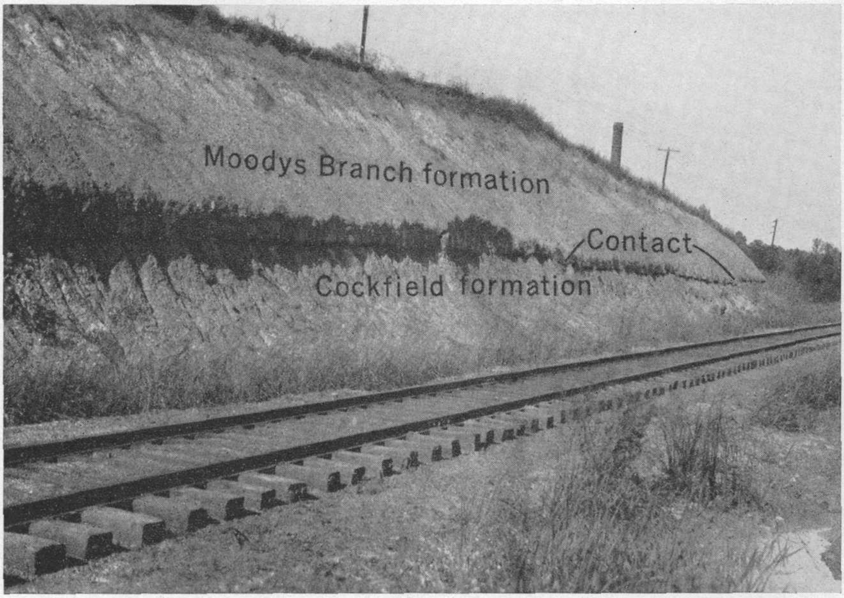

FIGURE 2.—Contact of the Moodys Branch and the Cockfield formations, cut of the Gulf, Mobile and Ohio Railroad near Jackson waterworks, sec. 35, T. 6 N., R. 1 E., Hinds County.

Moodys Branch is nearly horizontal, but beds in the Cockfield formation have an apparent southwest dip of 11°. It is probable that this strong dip is a form of cross bedding, probably delta foreset beds.

Origin.—Grim (1936, p. 195) postulates an origin of the Cockfield formation in a littoral or neritic environment, but the strong cross bedding seen at a few places within the Jackson area suggests that at least a part of the formation was deposited in the delta of an ancient river. Some less strongly cross-bedded sand beds, the carbonaceous clays, and the lignite beds might have been deposited in lagoons on the sides of the delta distributaries and in swamps where deposition had built the land above sea level for short intervals.

JACKSON GROUP

Jackson has long been a classic locality for collecting invertebrate fossils. As early as 1846 Sir Charles Lyell (1847, pp. 191; 1849, vol. 2, pp. 160–162) visited the city to obtain specimens from the marl (Moodys Branch) exposed in creeks near Jackson. Since then the deposits at Jackson have ranked second only to those at Claiborne, Ala., in the quality and variety of fossil shells available to collectors.

Conrad (1855, p. 257) was the first to refer these beds exposed at Jackson to a definite stratigraphic position midway between the Claiborne and Vicksburg groups. Hilgard (1860, pp. 128–135) accepted the name Jackson group for them, but made no attempt to divide the group into definitely named formations. His definition (1860, p. 128) of the group remains essentially the same today:

> The material to which this prairie soil owes its origin, possesses a considerable analogy to the Rotten Limestone [chalk of the Selma group] itself—at times, it is a soft yellowish limestone or indurate marl, containing a good deal of clay; at others, it is in reality, nothing more than a soft, gray or yellowish, calcareous clay. * * * * About 70 feet of rocks of this character form the upper division of the Jackson stage. The lower portion is formed by from 10 to 20 feet of sandy strata, commonly of a bluish tint, and containing greensand grains.

In 1915 Lowe (1915, pp. 78–84) subdivided the Jackson group into three formations: Yazoo clay marl, Moody's Branch green marl, and Madison sands. In 1918 Cooke (pp. 187–188) recommended that the Jackson be treated as a single formation with two members:

> The * * * two intergrade so much that it seems advisable to consider them members of a single formation rather than constituting independent formations. In the succeeding discussion they are called the Yazoo clay member and the Moodys calcareous marl member of the Jackson formation, of which the Yazoo clay is the upper and the Moodys marl the lower member.

He further proposed that Lowe's Madison sands be considered the basal formation of the Vicksburg group and that the name be changed to Forest Hill sand. In 1939 Cooke (1939, pp. 337–340) proposed that the Jackson formation be raised to the rank of a group containing two formations, the Moodys marl and the Yazoo clay. Mellen (1940, p. 16) considered the Jackson a formation containing the Moodys Branch member, the Yazoo member, and the Forest Hill member.

In the present paper the Jackson group is divided into the Moodys Branch formation and the Yazoo clay.

MOODYS BRANCH FORMATION

Name.—The name Moodys Branch was first used by Meyer (1885, p. 435), but the beds referred to were not defined. Harris in 1894 (p. 304) again used the name Moody's Branch Beds without defining the unit. In 1915 Lowe (pp. 80–82) suggested the name Moodys Branch green marls for the sandy beds cropping out in Moodys Branch and at the junction of Town Creek and the Pearl River at Jackson. As noted above, Cooke (1918, pp. 187–188) renamed the unit the Moodys calcareous marl. The name Moodys marl (the Geological Survey does not now use calcareous in connection with marl) was not generally accepted by geologists working in the region and in 1945 the U. S. Geological Survey adopted officially the older name Moodys Branch formation.

Areal distribution.—The Moodys Branch formation is exposed in a narrow band in and north of the city of Jackson. Its outcrop extends southward from sec. 23, T. 6 N., R. 1 E., and 30, T. 6 N., R. 2 E., along the eastern edge of the city to secs. 10 and 11, T. 5 N., R. 1 E. As is true of the Cockfield formation, the Moodys Branch is largely concealed by alluvium in the Pearl River valley. If the alluvium should be removed it seems reasonable to suppose that the easternmost exposures of the Moodys Branch would be a mile or more east in section 32, T. 6 N., R. 2 E. The formation has been traced from Yazoo and Holmes Counties on the west entirely across Mississippi into western Alabama.

Lithologic character.—In the unweathered state the Moodys Branch formation consists of blue-gray glauconitic, calcareous, highly fossiliferous, slighty clayey sand at the base grading upward into lighter blue-gray fossiliferous, sandy clay. Some layers are partly indurated into very clayey, sandy, glauconitic limestone. The formation merges upward into the Yazoo clay with no perceptible break. Where weathered, the formation consists of loose dark-red to yellow clayey sand, at many places containing recognizable prints of fossils and at some places cemented into soft ferruginous sandstone. Small quartz pebbles have been seen in the weathered Moodys Branch near Hillsboro, Scott County, east of the mapped area. At places where the formation has long been exposed to weathering it consists of red sandy clay.

The type section in Moodys Branch just south of the intersection of Peachtree Street with Poplar Boulevard in the northeastern section of Jackson has long been of interest to collectors of invertebrate fossils, and with the exposure in Town Creek at the south edge of the city is the source of most of the early collections of "Jacksonian" fossils. The section is described below:

Section in Moodys Branch south of intersection of Peachtree Street with Poplar Boulevard, Jackson, Miss.

	Feet
Yazoo clay and Moodys Branch formation: Clay, light-yellow to cream-colored, calcareous; containing impressions of mollusks; sparingly glauconitic and very plastic in upper part; grades downward into underlying beds	18
Moodys Branch formation: Sand, yellow to gray, glauconitic, slightly clayey, containing abundant fossils; about 6 feet above base calcareous nodules are common; in the basal foot are many small clay pebbles reworked from underlying formation	13
Unconformity (altitude is 276.5 feet).	
Cockfield formation: Clay, dark-gray to black carbonaceous; contains streaks of iron and flat, waterworn chips of lignite about ½x½x⅛ inches. The upper 3 inches of this clay is broken into blocks about 3 inches in diameter surrounded by the overlying fossiliferous sand; numerous borings in the upper part are filled with the overlying sand	3
	34

The most common species of fossil in the Moodys Branch formation is *Calyptraphorus velatus* Conrad.

Three cuts of the Gulf, Mobile and Ohio Railroad between the old State capitol and the Jackson waterworks afford good exposures of weathered Moodys Branch formation. The section at the northernmost cut (fig. 2) is described below:

Section in railroad cut at Jackson waterworks

	Feet
Moodys Branch formation: Sand, loose, light-brown, glauconitic, containing calcareous nodules and fossil shells; upper 11 feet contains much plastic clay with an indurated layer of very soft sandy limestone at its base; basal foot contains many balls of clay reworked from underlying Cockfield formation	27
Unconformity (altitude 288 feet).	
Cockfield formation: Clay, gray, sandy, containing excellently preserved fossil leaves in upper 3.5 feet; merging downward into fine gray sand; a 1-foot layer of carbonaceous clay at base; these beds have an apparent southwest dip of 11°, probably cross bedding	9
	36

There are many good exposures of the Moodys Branch formation on the banks and in the bed of Crane Creek secs. 23, 35, and 36, T. 6 N., R. 1 E., and on the left bank of Pearl River at the side of old U. S. Highway 80 along the south edge of sec. 11, T. 5 N., R. 1 E., Rankin County.

Thickness.—The Moodys Branch formation varies somewhat in thickness throughout the Jackson area but averages 25 feet in measured sections. In several sections near Jackson it appears to be somewhat thinner, possibly because of less deposition on the crest of the Jackson anticline. The probable contact of the Yazoo clay and the Moodys Branch is exposed in a creek bed at Riverside Drive just east of St. Marys Street in the SW¼NE¼NE¼ sec. 35, T. 6 N., R. 1. E., at an altitude of about 287 feet. An auger hole bored in the bottom of the creek reached Cockfield formation at 13.7 feet at an altitude of 265.3 feet, making a total thickness here of 22 feet of the Moodys Branch.

Fossil content.—The Moodys Branch formation is extremely rich in excellently preserved fossils. Cooke (1918, p. 190) has listed 200 species of mollusks and Vaughan has identified 12 species of corals from the exposures at Moodys Branch and Town Creek in Jackson. Canu and Bassler (1920, pp. 20–33) have identified 85 species of Bryozoa. A few species of echinoderms are extremely abundant[1] but they constitute a much smaller element in the fauna than they do

[1] Cooke, C. W., Unpublished manuscript on Jackson group in Mississippi.

in the Jackson deposits east of Mississippi. The deposits are also extremely rich in smaller foraminifers.

Representative suites of fossils may be collected from the Moodys Branch formation at the following places:

Gully in SW¼SW¼ sec. 25, T. 6 N., R. 1 E., Hinds County (one of the best localities near Jackson).

Moodys Branch just south of intersection of Peachtree Street with Poplar Boulevard, SW¼ sec. 35, T. 6 N., R. 1 E., Hinds County (type locality).

Town Creek at extension of South State Street and 200 yards upstream, SW¼SE¼ sec. 10, T. 5 N., R. 1 E., Hinds County.

Left bank of Pearl River just north of old U. S. Highway 80, SW¼ sec. 11, T. 5 N., R. 1 E., Rankin County.

Three cuts of Gulf, Mobile and Ohio Railroad between old State Capitol and Jackson waterworks, SE¼ sec. 35, T. 6 N., R. 1 E., and NE¼ sec. 2, T. 5 N., R. 1 E., Hinds County.

Stratigraphic relations.—The Moodys Branch formation rests with marked disconformity on the Cockfield formation. It grades upward without a definite break into the overlying Yazoo clay. The upper contact in this report has been rather arbitrarily placed at a point where the sand and glauconite content becomes negligible and above which fossils are found mostly as impressions in the clay.

Origin.—The Moodys Branch formation constitutes the basal conglomerate initiating the Jackson cycle of deposition. Its fauna suggests near shore conditions. As deposition proceeded in Moodys Branch time apparently less and less sand was available and the deposits became more clayey.

YAZOO CLAY

Name.—Lowe, in 1915 (p. 79), named the upper part of the Jackson group the Yazoo clay marl and the name was shortened by Cooke in 1918 (pp. 186–189) to Yazoo clay member of the Jackson formation. In 1939 Cooke raised Yazoo to formational rank. The formation is named for exposures on the bluff of Yazoo River at Yazoo City, Miss.

Areal distribution.—The Yazoo clay crops out in a wide belt between the outcrops of the Moodys Branch formation and the Forest Hill sand. It crops out over the eastern part of the Raymond quadrangle; over most of the Jackson quadrangle, except in the northwestern and southeastern portions where it is overlain by the formations of Oligocene age, in stream valleys where it is overlain by alluvium, and in the eastern part of the city of Jackson where older beds crop out; in the northern part of the Florence quadrangle; and in the northern two-thirds of the Pelahatchie quadrangle. The Yazoo clay is present near the surface over a larger part of the mapped area than any other formation except the brown loam (weathered loess).

The Yazoo extends across Mississippi in a rather wide belt of outcrop from Yazoo County on the west to Clarke County on the east.

Lithologic character.—The Yazoo clay in its unweathered state consists of blue-gray and greenish-blue calcareous clay containing very soft and thin fossil shells, abundant foraminifers, and scattered grains of pyrite. At a few places the formation is sandy, but this is exceptional. In the upper part of the formation one or more layers of soft marly limestone have been seen.

Where weathered the formation consists of gray to greenish-yellow or very light olive-green clay commonly very calcareous and containing black stains of manganese oxide (wad) in the joints. Calcareous nodules, ranging in size from microscopic specks to as much as an inch in diameter, are very common at the surface. Gypsum crystals in the clay are probably formed by reaction with the lime of sulphuric acid released by disintegration of the pyrite. The crystals are common to a depth of about 30 feet, but according to local drillers gypsum is never encountered below that depth.

The only places where fresh Yazoo clay has been seen cropping out, are in creek beds and in the banks of the Pearl River. Three exposures near Jackson are worthy of note. In the bed of Town Creek 300 feet west of Gallatin Street in sec. 4, T. 5 N., R. 1 E., 4 feet of light gray clay, very calcareous and very fossiliferous, containing no glauconite and no sand, is overlain by 10 feet of alluvium—sand, silt, and gravel. On Hanging Moss Creek, 100 feet north of the junction with Whiteoak Creek in the SW¼SE¼NE¼ sec. 18, T. 6 N., R. 2 E., Hinds County, Yazoo clay is exposed in the bank of the creek overlain by alluvium. Here the Yazoo consists of plastic blue-green massive calcareous clay weathering to brown and later to a cream color. The fresh clay contains numerous prints of pelecypods.

On a trip down the Pearl River in August 1939 the following exposures of Yazoo clay were seen: On the right bank of the river a hundred feet below the bridge of the Gulf & Ship Island Railroad near the center of sec. 15, T. 5 N., R. 1 E., Hinds County, 4 feet of greenish-gray, very slightly sandy, calcareous clay, containing abundant soft fossils and pyrite, is overlain by 21 feet of alluvium. On the left bank at a sharp bend to the south in the NE¼ sec. 22, T. 5 N., R. 1 E., Rankin County, 3 feet of slightly sandy, slightly pyritiferous and very calcareous clay is overlain by alluvium. On the left bank at a bend to the south-southwest in the SW¼NW¼NE¼ sec. 33, T. 5 N., R. 1 E., Rankin County, a foot of noncalcareous blue-green very finely sandy clay is exposed containing a fragment of a fossil shell. This material resembles Forest Hill sand more than Yazoo clay, but it is so far north of the outcrop of the Forest Hill that the writer decided that the deposit must be a sandy facies of Yazoo clay; the possibility of faulting that could bring Forest Hill down to river level at this point is recognized, but there is no evidence of faulting in the uplands on either side of the Pearl River flood plain. Two-tenths of a mile south-southwest at a bend toward the west on the left bank in the NW¼SE¼NW¼ sec. 33, T. 5 N., R. 1 E., Rankin County, about 2 feet of blue-green calcareous fossiliferous clay that is not sandy and is characteristic of the Yazoo is exposed. The next exposure down the river is just below a bend to the south on the left bank near the center of the SW¼SW¼ sec. 34, T. 5 N., R. 1 E., Rankin County, where 2 feet of greenish blue-gray, calcareous clay, containing a little finely disseminated pyrite, is exposed. Just below the mouth of Richmond Lake on the left bank of the river in the SE¼SE¼NW¼ sec. 3, T. 4 N., R. 1 E., Rankin County, a bed of soft blue limestone, marly and fossiliferous, dips about 6° downstream under water level. Within the next 400 feet, two similar beds are exposed.

Whether these layers of marl represent the same bed repeatedly faulted above water level, or three distinct layers could not be determined. The critical places between the beds of marl were concealed by slumped clay or alluvium at each visit. Small faults have been seen 1½ miles down the river affecting Forest Hill sand and consequently it seems probable that there is only one marl bed which has been faulted at two places. About 1,000 feet below the preceding exposure, about 6 feet of greenish-blue clay containing abundant well-preserved very thin shelled fossils affords a good collecting locality for those interested in the larger fossils of the Yazoo clay. Forest Hill sand, consisting of 7 feet of blue clay containing thin laminae of very fine sand and silicified wood, was exposed on the right bank at the bend due east in the NE¼NW¼SW¼ sec. 10, T. 4 N., R. 1 E., Hinds County, but half a mile east at Tucker Bluff on the left bank in the NE¼NW¼SE¼ sec. 10, Rankin County, hard dark-green and fossiliferous Yazoo clay is exposed. No exposures of Yazoo clay were seen on Pearl River below Tucker Bluff.

A shell bed similar to that described above and possibly continuous with it was reached in an auger hole bored as a test for water on the farm of J. G. White in the SE¼SE¼NE¼ sec. 10, T. 5 N., R. 2 E., Rankin County. The auger penetrated a surficial deposit of sand, brown loam (weathered loess), yellow clay containing gypsum, and stopped at 48 feet in the fossiliferous blue-gray clay.

The soft marly limestone seen just below the mouth of Richmond Lake, stratigraphically below the shell bed already described, has also been seen in the mapped area on the northward-facing slope of a hill in the NW¼SW¼NE¼ sec. 12, T. 7 N., R. 1 E., Madison County and at a locality on the Pelahatchie-Leesburg road in the SW¼NE¼NE¼ sec. 9, T. 6 N., R. 5 E., Rankin County.

Bay (1935, pp. 40–42) reported bentonite(?) in the Yazoo clay in Hinds County on U. S. Highway 51, 3.7 miles south of its junction with Mississippi Highway 18, just north of Caney Creek School (sec. 31, T. 5 N., R. 1 E.). "The clay, 1 foot thick, is light greenish-gray, waxy, and hard and brittle." Concerning bleaching clays in the Jackson group Bay makes the following statement:

The Yazoo clay member of the Jackson formation is characterized by two zones that are probably bentonitic—one in the very base of the member, and above the greensands of the Moodys marl member; the other near the top of the Yazoo. Both zones are local and do not extend throughout the outcrop of the Yazoo clay. Although recognizable shards of volcanic ash are lacking in the thick plastic clay beds that characterize the Jackson formation, the fact that numerous samples collected at random over the outcrop are all somewhat activable suggests that some ash was being contributed throughout the deposition of the Yazoo clays, and that during two periods there were relatively heavy concentrations of ash.

Mellen (1940, pp. 20, 39; McCutcheon, 1940, p. 93) described bentonitic clay from the upper part of the Yazoo clay and found the bed a good stratigraphic marker. So far as the writer has been able to ascertain none of these occurrences of bentonite have shown any shards of volcanic glass although one of Mellen's test holes (No. C–11) penetrated clay containing biotite (McCutcheon, 1940, p. 93)—a good sign of ash in the Coastal Plain.

Thickness.—The Yazoo clay is thickest in the western part of the Jackson area and thins toward the east. The Gulf Refining Co. of Louisiana in 1930 drilled a core hole at Rocky Hill Church near the center of sec. 20, T. 7 N., R. 1 E., Madison County, that penetrated the Forest Hill sand, the Yazoo clay, the Moodys Branch formation, and stopped in the Cockfield formation. The log of this hole is given on pages 65–66. In this hole the Yazoo clay is 415 feet thick and is underlain by 25 feet of Moodys Branch formation—a total thickness for the Jackson group of 440 feet.

The well of the Central States Power Co. at Brandon apparently penetrated 424 feet of the Jackson group, of which about 400 feet should be assigned to the Yazoo clay, although the log shows about 412 feet of "blue shale and soapstone."

A well drilled in 1936 at Gulde School in the SW¼SE½SW¼ sec. 2, T. 5 N., R. 4 E., Rankin County, reached the base of the Yazoo clay at a depth of 383 feet or 5 feet above sea level. Study of the outcrops of the contact of the Yazoo clay with the overlying Forest Hill sand near Gulde School shows that the altitude of the contact at the well should be about 370 feet above sea level. The thickness of the Yazoo at Gulde, then, is approximately 365 feet.

A well at the Adams-Banks Lumber Co. at Morton, Scott County, apparently reached the Moodys Branch formation at a depth of 300 feet or 155 feet above sea level. As the contact of the Yazoo clay and Forest Hill sand at the site of the well appears to be about 505 feet, the thickness of the Yazoo here is probably about 350 feet.

Fossil content.—The only macrofossils collected from the Yazoo clay in the Jackson area are from a dug well on the farm of J. G. White in the SE¼SE½NE¼ sec. 10, T. 5 N., R. 2 E., Rankin County, and on the left bank of Pearl River near the center of sec. 3, T. 4 N., R. 1 E., Rankin County. The fossils have been identified by F. Stearns MacNeil who makes the following report:

Fossils from dug well of J. G. White:
Nucula sp.
Nuculana n. sp. (definitely not the common Red Bluff *Yoldia*)
Nemocardium n. sp.

Fragments of the *Nemocardium* show it to bear very fine spines along the anterior edge of the last few posterior radiating ribs, thus differing from *N. nicolletti* (Conrad) from the Moodys marl in which the spines are coarser, developed on all of the posterior riblets, and situated more squarely upon them. The Red Bluff species, likewise undescribed, has no spines on the posterior radiating ribs, but has thin, raised, concentric growth lines which form raised partitions between the ribs giving the posterior slope a latticed appearance.

Presumably the Yazoo species represents an intermediate stage between the Moodys marl and Red Bluff species, and if so it is a stage in which the spines have not yet become obsolete, and the concentric partitions have not yet developed. If anything, I would say the Yazoo species is more closely related to the Moodys marl species.

Near the base of the Yazoo clay north of Jackson and in the northern part of the Pelahatchie quadrangle are beds from which large numbers of *Ostrea trigonalis*, bryozoa, and calcareous algae weather out of the clay and are found on the surface of the ground.

The best known fossil from the Yazoo clay is the Zeuglodon, *Basilosaurus cetoides* (Owen), a large whalelike mammal whose remains are common at many places in the upper part of the formation.

Stratigraphic relations.—The Yazoo clay merges downward into the Moodys Branch formation; the writer has placed the contact at the horizon where the sand content of the Moodys Branch becomes negligible. The Yazoo is overlain by the Forest Hill sand of Oligocene age. At some of the places where the contact has been seen the two formations appear to grade one into the other and possibly to intertongue, but at others there appears to be a sharp contact. In auger holes that have passed from the Forest Hill into the Yazoo the sequence is as follows: typical greenish-gray calcareous clay (Yazoo), overlain by about a foot of noncalcareous flaky gray clay (transition?), overlain by laminated sand and clay deposits (Forest Hill). The only places where the writer has seen a sharp contact between the Yazoo and Forest Hill are in exposures north and northwest of Pelahatchie. In that area the Forest Hill sand appears to have been deposited in a shallow channel cut into the Yazoo clay. Possibly at some places the lower part of the Forest Hill sand may have been deposited at the same time as the upper part of the Yazoo elsewhere, for the Forest Hill is a deltaic deposit that succeeded the more open water deposit of the Yazoo clay. The Forest Hill sand as a whole, however, is certainly not of Jackson age.

Origin.—The Yazoo clay appears to have been deposited fairly near shore in a region where a large amount of clay was being brought into the sea by a large river, or by several rivers. Toward the east in Mississippi the formation becomes more calcareous and in western Alabama it merges laterally into the Ocala limestone, a formation that was deposited in relatively clear water. The soft marly limestone seen at a few places was doubtless deposited at a time when the clay content of the sea water was less than usual.

Physiographic expression.—The Yazoo clay forms the Jackson Prairie belt, which lies between the North Central Hills and the Southern Pine Hills. Actually only isolated areas varying in size from a few acres to several square miles are true grassland prairie, and much of the belt was originally forested, but the belt is so generally flat and treeless at present that the term prairie seems appropriate.

The relief of the belt is very low; north of Morton in Scott County some of the slopes have a gradient of less than 20 feet to the mile and steep slopes are common only near large streams. This low relief is partly due to erosibility of the clay and partly to the tendency of the clay when it is wet to slip and flow even on gentle slopes, thus tending to flatten any steep slope. This slippage is the cause of some very uneven streets in Jackson and the warping and cracking of many houses that have been built on the clay. Morse (1935, p. 13) has described landslides that have affected the city reservoir, railroads, and highways at Yazoo City because of the slippage of Yazoo clay.

An unusual type of landslide was observed on the south side of Ware Hill, sec. 30, T. 6 N., R. 5 E., Rankin County. Here the weight of the hill to the north has caused the Yazoo clay to slip resulting in a series of cracks en échelon. Many of these cracks are deeper than 10 feet; they are accompanied on their down-slope sides by small ridges on which trees have been tilted (Monroe, 1932a, pp. 214–215).

OLIGOCENE SERIES

The rocks of Oligocene age in Mississippi include the Forest Hill sand and its equivalent the Red Bluff clay, the Marianna limestone, the Byram formation, and the Chickasawhay limestone. Until 1941 all these formations were included in the Vicksburg group, but, partly because of F. Stearns MacNeil's work, it seemed better to restrict the name Vicksburg group to the limestone formations—the Marianna limestone and the Byram formation. These formations constitute the rocks loosely termed "Vicksburg limestone" named from the excellent exposures on the bluffs at Vicksburg, Miss. This change makes the Vicksburg group more nearly a lithologic rather than a time unit. Furthermore, the Forest Hill sand and the Chickasawhay limestone are separated from the Vicksburg group by important unconformities.

FOREST HILL SAND

Name.—Cooke (1918, pp. 192–193) suggested the name Forest Hill sand for the beds exposed near Forest Hill School, secs. 22 and 23, T. 5 N., R. 1 W., Hinds County. This name replaces the preoccupied name, Madison sands, suggested by Lowe (1915, pp. 82–84) for beds "sandwiched between the Jackson marine beds and the marine marls of the overlying Vicksburg group." Lowe and later Mellen (1940, pp. 16, 23) included the formation in the Jackson because they were apparently unfamiliar with the stratigraphic relations on Chickasawhay River between Hiwannee and Boyce, Wayne County, Miss., where the Forest Hill sand lies between the Oligocene Red Bluff clay and the Marianna limestone.

Areal distribution.—The Forest Hill sand is exposed between the outcrops of the Yazoo clay and the Mint Spring marl member of the Marianna limestone in the northern half of T. 7 N., R. 1 E.; thence south, east, and north in a great circle extending nearly seven-eighths of the way around the Jackson dome to the southeastern part of T. 6 N., R. 2 E.; thence east-southeast through T. 6 N., R. 3 E., Ts. 5 and 6 N., Rs. 4 and 5 E., into Scott County.

The Forest Hill sand crops out in a belt across Mississippi from Yazoo County on the west through Hinds, Rankin, Scott, and Smith Counties in which area it is interposed between the belts of outcrops of the Yazoo clay and the Mint Spring marl member of the Marianna limestone. From eastern Smith County to the Alabama line through Jasper, Clarke, and Wayne Counties the Forest Hill sand is underlain by and may interfinger with the Red Bluff clay. The formation has been reported (Blanpied, Oldham, and Alexander, 1934, p. 10), from western Alabama.

Lithologic character.—The Forest Hill sand consists predominantly of thin-bedded and thinly laminated light-gray, cream-colored, yellow, rarely pink or red, micaceous, very fine sand. Some parts of the formation contain thin laminae and thicker beds of gray plastic clay and finely sandy clay (fig. 3.) Two prominent beds of lignite, locally containing considerable clay, are present near the top of the formation and in a few places a bed of carbonaceous clay, possibly an old soil zone,

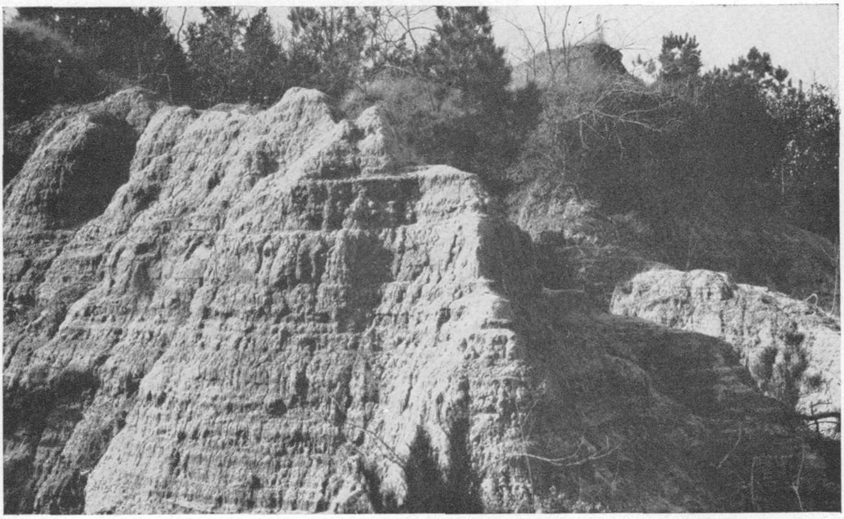

FIGURE 3.—Forest Hill sand overlain in pillar in background by brown loam (weathered loess); gully north of public road in SW¼NW¼ sec. 2, T. 7 N., R. 1 E., Madison County.

has been seen near the base of the formation. In the unweathered state most of the Forest Hill sand is light blue to light blue gray excepting a few beds of white sand, and of course, the carbonaceous layers. Where weathered, the formation is light gray, yellow, and light red and contains between the bedding planes, abundant paper-thin plates of impure limonite. Silicified wood, scattered over the surface of the formation, is common, and has been seen in place in the formation at a few places. Locally the formation is crossbedded and at a few places the thin beds dip so steeply and so regularly that the strike and dip may be measured (fig. 4)—some of these steep dips, however, are original. Some parts of the formation contain abundant crystals of gypsum, generally smaller than those found in the underlying Yazoo clay.

The upper few feet of the Forest Hill sand contains fossil shells, but these have been seen only in relatively fresh exposures in stream banks. Some other parts of the formation may also have been deposited under marine conditions, for small calcareous concretions have been found scattered on the surface of clay of the formation.

The type locality is on the Jackson-Raymond road, ¼ mile northeast of Forest Hill School in the NE¼ sec. 22, and the NW¼ sec. 23, T. 5 N., R. 1 W., Hinds County. Here only the upper part of the formation is well exposed; the lower part and the contact with the

FIGURE 4.—Beds in the Forest Hill sand dipping 26° S. 70° W., left bank of branch of Lime Creek, sec. 15, T. 4 N., R. 1 E., Rankin County.

underlying Yazoo clay is covered by material washed down the slopes and by brown loam (weathered loess). The following section is exposed at the type locality:

Section ¼ mile northeast of Forest Hill School

	Feet
Byram formation, Glendon limestone member: Limestone, hard, cream-colored, weathering into chocolate-brown sandy clay with black streaks of wad; to top of hill including a little brown loam	10.0
Marianna limestone, Mint Spring marl member:	
Marl, alternating hard and soft beds similar to underlying bed but containing more unweathered lime	6.5
Sand, brown, slightly glauconitic, calcareous, clayey, fossiliferous, containing large calcareous concretions (as much as 6 inches long); passes without a break into overlying marlstone; in basal part are pebbles of the underlying gray clay	3.2

Disconformity (altitude at middle of exposure is 435.0 feet).

Section ¼ mile northeast of Forest Hill School—Continued

	Feet
Forest Hill sand:	
Clay, gray, stratified, containing limonitic and calcareous plates and calcareous concretions in bedding planes and joint cracks; in upper 2 feet are many borings filled with overlying sand	5.5
Clay, carbonaceous; and lignite	0.5
Sand, plastic, yellow-gray, clayey, with 2-inch bed of lignite a foot above the base, merging upward into laminated sand and clay, in turn merging upward into massive yellow and white fine sand	10.0
Sand, massive beds, gray and yellow, mealy, with laminated sand and gray clay at base	2.2
Sand, massive, gray, fine; irregularly stained with yellow	6.5
Sand, plastic, gray, clayey	1.0
Clay, plastic, black, carbonaceous	0.6
Sand, plastic, gray, clayey	1.0
Sand, fine, gray and yellow, mealy, laminated and banded, carbonaceous in some thin beds; contains much paper-thin limonite in bedding planes	21.5
	68.5

The altitude of the disconformity between the Forest Hill sand and the Mint Spring marl member of the Marianna limestone was measured at several places near by and the dip was found to be from about 170 to 190 feet per mile to the southwest. As an auger hole bored 730 feet northeast of this disconformity reached the Yazoo clay at an altitude of 374 feet, the calculated thickness of the Forest Hill here is between 75 and 85 feet. If the rate of dip is slightly greater the thickness may be 100 feet, which seems to be about the average thickness of the formation.

North and northwest of Jackson in T. 7 N., R 1 E., are many good exposures of the Forest Hill sand. The Gulf Refining Company drilled a core hole at Rocky Hill Church in the NE¼NE¼SW¼ sec. 20, T. 7 N., R. 1 E., Madison County. Descriptions of cores from this hole are given below:

Description of cores from hole at Rocky Hill Church, Madison County

[Published by courtesy of the Gulf Refining Co. from descriptions by H. N. Toler]

	Thickness (feet)	Depth (feet)
Vicksburg group and Forest Hill sand: Clay, yellow (not cored)	34	34
Forest Hill sand:		
Clay, yellow to brown, sandy	4	38
Sand, blue, clayey, fine-grained, rather sticky; a slight amount of carbonaceous material and mica present	6	44
Sand, bluish-gray, fine-grained, slightly clayey in places, containing an abundance of mica and some carbonaceous material; appears to be laminated	10	54

Description of cores from hole at Rocky Hill Church, Madison County—Continued

Forest Hill sand—Continued	*Thickness (feet)*	*Depth (feet)*
Sand, dark-gray to slightly brownish, fine-grained, micaceous, small amount of carbonaceous material present; a few thin sandy clay layers are scattered through section	15	69
Clay, blue, stiff, sticky, resembles Yazoo clay	2	71
Sand, highly carbonaceous, dark-gray; and sandy clay	0.5	71.5
Lignite, brown	0.5	72
Clay, gray to bluish-green, fine, sandy, very little mica present and no carbonaceous material	2	74
No core recovered	6	80
Sand, medium fine-grained, blue to bluish-green, micaceous	4	84
No core recovered	6	90
Sand, gray, medium fine grained, carbonaceous and micaceous	2	92
Sand, gray, fine-grained, highly carbonaceous with thin streaks of lignite present	2	94
No core recovered	5	99
Sand, lignitic	1	100
Sand, fine light-gray	1	101
Sand, gray to greenish-gray, medium fine	3	104
No core recovered	7	111
Sand, gray, fine-grained, carbonaceous and micaceous, with two thin sandy clay layers present	3	114
Sand, gray to bluish-gray, fine-grained, micaceous and very carbonaceous	5	119
Clay, blue to bluish-green, sandy, and clayey sand; micaceous and slightly carbonaceous; rather stiff and compact; shows faint lines of lamination	5	124
Yazoo clay and Moodys Branch formation:		
Clay, blue, stiff, no sand, no mica or carbonaceous material present; Moodys Branch at base	440	564
Cockfield formation.		

Road cuts down the hill west of the church reveal the same section except that the material is highly weathered and there has been some slumping of beds, particularly in the lower part near the contact with the Yazoo clay.

Eighty-eight feet of Forest Hill sand is exposed on a hilly slope in the NW¼ sec. 16, T. 7 N., R. 1 E., Madison County. Here the section exposed is much like that at the type locality. Comminuted plant remains are common in some beds.

Fairly steep dips, probably original dips, are exposed at a few places in this part of the mapped area. In the NW¼SE¼SE¼ sec. 35, T. 8 N., R. 1 E., Madison County, the bedding of the Forest Hill sand dips 11° N. 10° W. In gullies in the NW¼SW¼NW¼ sec. 2, T. 7 N., R. 1 E., Madison County, the beds dip 6° W. Here the Forest Hill sand is overlain by a thin mantle of surficial gray to red sand and gravel which in turn is overlain by 12 feet of brown loam (weathered loess).

The contact of the Forest Hill sand with the Yazoo clay is poorly exposed on U. S. Highway 51 at Caney Creek School, SW¼SW¼-NE¼ sec. 31, T. 5 N., R. 1 E., Hinds County, at an altitude of 316 feet. The contact, so far as it can be seen, is not sharp; calcareous yellow clay of the Yazoo is overlain by sandy clay that merges upward into thinly laminated very fine sand.

In the southwestern part of the area the contact of the Forest Hill sand with the underlying Yazoo clay is probably best exposed in gullies in the NE¼NW¼NE¼ sec. 26, T. 5 N., R. 1 W., Hinds County, on the northeast side of a county road about a tenth of a mile northwest of a road fork. The following section is exposed:

Section in gullies a mile southeast of Forest Hill School

	Feet
Brown loam (weathered loess)	3
Forest Hill sand:	
Sand, gray, fine, and clay containing silicified wood	15
Clay, light brown, carbonaceous, and light-brown lignite	1
Yazoo clay (?):	
Sand, yellow and gray, and clay grading downward into light-gray noncalcareous clay; in upper part extending downward from overlying lignite, this bed contains long tubes, presumably root holes, 1/16 to ¼ inch in diameter filled with gypsum crystals	5±
Clay, yellow, sandy	2±
Yazoo clay: Clay, light-gray, containing calcareous nodules	1

On the Pearl River, during a boat trip taken on July 5, 1936, exposures of Forest Hill sand were seen from half a mile west of Tucker Bluff in sec. 10, T. 4 N., R. 1 E., to Hemphill Bluff in sec. 20, T. 4 N., R. 1 E. These exposures are described in detail below:

On the right bank in the NE¼NW¼SW¼ sec. 10, T. 4 N., R. 1 E., Hinds County, at the western end of the exposure is light-blue clay containing prints of fossil shells (Yazoo clay) overlain by light-blue clay without fossils that merges upward into hackly gray clay of a kind common in the Forest Hill sand; there is no evidence of a break in deposition in this section. In the middle of the exposure some thin-bedded very fine sand dips steeply and appears to be faulted. This sand contains a little silicified wood. At the eastern (downstream) end of the exposure the Yazoo clay passes under water level, but 50 feet farther down stream Yazoo clay again rises above water level. Much minor faulting probably accounts for the abnormal dips, but the maximum displacement of strata seems to be only a few feet; at one place the basal Forest Hill sand has been faulted against Yazoo clay.

At the south end of Tucker Bluff on the left bank in the NE¼ NW¼SE¼ sec. 10, 3 feet of light-blue fossiliferous Yazoo clay is overlain by light-blue unfossiliferous clayey Fores Hill sand. Here the change is also gradual with no evidence of a break in deposition.

Chance Spring in the NW¼NE¼NW¼ sec. 15, T. 4 N., R. 1 E., Rankin County, flows from the base of the alluvium on top of 2–3 feet of massive light gray-blue very fine sandy silt. One-tenth of a mile below the spring a 1-foot bed of lignite rests on gray sand. This may be the lignite bed near the top of the Forest Hill sand.

On the right bank in the NE¼SE¼SE¼ sec. 9, T. 4 N., R. 1 E., Hinds County, several springs flow from the alluvium over light-gray plastic very fine grained micaceous, carbonaceous clayey sand.

On the right bank in the NW¼NE¼NE¼ sec. 16 are thin horizontal beds of fine sand.

On the right bank at a sharp bend in the NE¼SE¼NW¼ sec. 16 thin-bedded sand dips 12° N. 65° E. This steep dip is probably an original dip, a form of crossbedding.

On the right bank about a quarter of a mile downstream on a south-southwest reach in the SE¼SW¼NW¼ sec. 16 a small exposure of 6 to 8 feet of massive sand is weakly stratified in beds about 18 inches thick. The sand is medium-gray, slightly bluish, very fine-grained, and finely micaceous.

The last exposure of Forest Hill sand on Pearl River is in a gully at the west end of Hemphill Bluff in the NE¼NW¼NE¼ sec. 20, T. 4 N., R. 1 E., Rankin County, where 14 feet of bedded black clay of the Forest Hill sand is disconformably overlain by a foot of fossiliferous Mint Spring marl member of the Marianna limestone. The contact is not exposed in the three-quarter mile straight stretch of the river below the bluff.

Excellent exposures of the lower part of the Byram formation, the Mint Spring marl member of the Marianna limestone, and the Forest Hill sand are exposed on a branch of Lime Creek near the south edge of sec. 15, T. 4. N., R. 1 E., Rankin County. The accompanying sketch map (fig. 5), prepared from a pace-compass traverse, shows the approximate plan of the creek for about 1,500 feet (airline) downstream from a waterfall in the SW¼SW¼SE¼ sec. 15. The waterfall is designated "A" and other places discussed in the text below are designated by succeeding letters to "N". The section at the waterfall and in a bluff about 50 feet up the creek from the waterfall is described below:

Section at waterfall on branch of Lime Creek, sec. 15, T. 4 N., R. 1 E.

	Feet
Byram formation, Glendon limestone member:	
12. Limestone, hard, cream-colored, glauconitic, some limonite	0.7
11. Marl, very granular and soft, slightly glauconitic, limonitic, cream-colored; at base is shell bed containing *Pecten byramensis*	3.5
10. Marlstone, hard, cream-colored, containing considerable glauconite and a few impressions of fossils	1.0
9. Marl, soft, white, containing some glauconite and a few sand grains	3.3
8. Marlstone, white, containing some glauconite and rounded sand grains	.7
7. Marl, coarsely and abundantly glauconitic, soft, blue, sandy, much finely disseminated pyrite; 9 inches below top is a lens of asphalt 1 foot long and ¾-inch thick; *Pecten byramensis*	3.5
Diastem(?).	
Marianna limestone, Mint Spring marl member:	
6. Limestone, hard, coarsely sandy, and glauconitic (or limy sandstone), containing much phosphatic material and many shell fragments; *Pecten poulsoni*	3.0
5. Sand, soft blue-gray, highly glauconitic, angular to subrounded fine-grained; contains considerable phosphatic material; bottom foot contains abundant water-worn *Pectens* and oysters and a few clay pebbles reworked from underlying bed; *Pecten poulsoni* and *Ostrea vicksburgensis*	6.0
Disconformity. (contact is sharp and undulating, altitude, 260.0 feet; (see fig. 6)	
Forest Hill sand:	
4. Clay, dark-gray, pyritiferous, cross-bedded, finely sandy, containing numerous fossils; angular to subangular sand grains; a few very small grains of glauconite; upper part has many borings leading downward from the overlying Mint Spring marl filled with the glauconitic, fossiliferous sand above; at places this Mint Spring sand has accumulated in small lenses at the bottoms of the borings	2.5±
3. Sand, thin-bedded, dark-gray, micaceous, clayey; splits in large thin sheets	2.5±
2. Lignite, compact, black and brown	.6
1. Sand, massive, gray, very fine grained, silty	2.5±

On the sketch map (fig. 5) beds 6 to 12 of the section above are exposed at "A," beds 3 to 5 at "B," and beds 1 and 2 at "D". The fossiliferous part of the Forest Hill sand is exposed as far downstream as "C".

At "E" a bed of massive, very fine grained sand, 3 feet thick is exposed. The same bed is exposed at "F" but here it is slightly bluer in color. At "G" a waterfall exposes a 4-foot layer of very fine grained, light blue-gray, sandy silt overlain by a 1-foot bed of brownish-gray

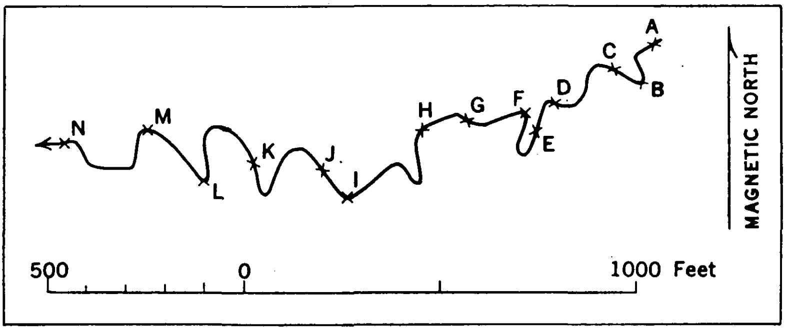

FIGURE 5.—Plan of exposures of Forest Hill sand and Vicksburg group on Lime Creek, sec. 15, T. 4 N., R. 1 E., Rankin County.

sandy clay containing comminuted plant remains. Massive blue sand containing a few leaves is exposed at "H". At "I" fine blue sand shows ripple marks. The bedding begins to dip steeply at "J". At "K" beds of fine, slightly ripple-marked, light-blue sand dip at a rate of 26° S. 70° W. (fig. 4). The strike of N. 20° W. continues down the creek and was observed at "L" and "M". At "L" the bedding dips 34° from top to bottom of a bank 15 feet high; at "M" the dip is 20°. At "N" nearly horizontal strata rest on the dipping beds proving that this strong dip is a form of crossbedding or that the structural movement took place during deposition. Pearl River alluvium here overlies the flat beds of the Forest Hill sand. From "N" the bedding dips gently downstream.

The writer believes that these steeply dipping beds of the Forest Hill sand represent a submarine slide that took place during deposition on a distributary of a delta, and probably most of the steep dips encountered in the Forest Hill either have a similar origin or are foreset beds of a delta distributary. On the old Brandon-Jackson highway in the SW¼SE¼NW¼ sec. 11, T. 5 N., R. 2 E., Rankin County, 11 feet of gray and white, finely laminated, fine-grained sand together with reddish-brown ferruginous sand, containing some gray clay dips 24° N. 25° W. This material weathers first to grayish-red sandy clay and then to massive red clayey sand. On U. S. Highway 80 in the SW¼SE¼NW¼ sec. 9, T. 5 N., R. 4 E., Rankin County, the bedding has a westerly dip of 10°.

The upper part of the Forest Hill sand is well exposed in a railroad cut at the Rankin station in the N½NE¼SE¼ sec. 8, T. 5 N., R. 4 E., Rankin County, but the overlying Mint Spring marl member of the

Marianna limestone has here been weathered to hard limonitic sand stone. The section of the lower part of the cut is described below:

Section of Forest Hill sand exposed in railroad cut east of Rankin, Rankin County, Miss.

	Ft	in
Sand and clay, thin-bedded; one bed of gray clay contains numerous crystals of gypsum and impressions of pelecypods	2+	
Clay, carbonaceous	1	6
Sand, yellow and gray, laminated, containing a little interbedded clay	4	
Lignite		2
Clay, gray, carbonaceous, containing poorly preserved leaves in upper part	2	
Sand, gray, laminated	5	
	14	8

The base of the Forest Hill sand is exposed on the Brandon-Fannin road in the NW¼SE¼NE¼ sec. 22, T. 6 N., R. 3 E., Rankin County; gray and drab-yellow calcareous clay of the Yazoo is overlain by laminated sand and clay of the Forest Hill containing near the base a thin bed of clay resembling Yazoo clay and containing calcareous nodules. This exposure suggests that the Forest Hill sand and the Yazoo clay not only merge vertically one into the other, but may intertongue to a slight extent.

Thin-bedded pink and gray clay, yellow sand, and highly cross-bedded, compact yellow and red fine sand containing clay pellets is exposed on Ware Hill, sec. 24, T. 6 N., R. 4 E., Rankin County. An auger hole bored on the west side of the hill passed from this sand into weathered Yazoo clay. The weathering may be due to ground-water action or to pre-Forest Hill weathering, but this is one of the few places where the contact of the Forest Hill and the Yazoo suggests unconformity. Contours drawn on the contact of the Yazoo and the Forest Hill in the areas northwest and north of Pelahatchie show a deep reentrant, which may represent a syncline or a pre-Forest Hill channel cut into the Yazoo clay. The sharp contact of Forest Hill on Yazoo at Ware Hill and a few similar contacts on the hills north of Pelahatchie suggest that this is a channel, but proof would depend on obtaining records of many wells drilled through the Jackson, so that contours could be drawn on the top of the Cockfield formation.

Thickness.—In general the thickness of the Forest Hill sand appears to be about 100 feet in the Jackson area. The thickest measured section of the formation is about 100 feet on the long hill west of Rocky Hill Church in secs. 19 and 20, T. 7 N., R. 1 E., Madison County. The formation may be somewhat thicker south of Pelahatchie in T. 5

N., R. 5 E., Rankin County, but no accurate measurements are available. The thinnest section is at the type locality at Forest Hill School in secs. 22 and 23, T. 5 N., R. 1 W., Hinds County, where the calculated thickness is between 75 and 85 feet. If the measurements of the rate of dip are not accurate and the dip is as much as 200 feet per mile, the thickness of the formation at Forest Hill School is about 100 feet.

Fossil content.—Fossil mollusks have been collected only in the upper few feet of the Forest Hill sand. F. Stearns MacNeil has studied the meager fauna from the upper part of the formation and his identifications will be published in his monograph in preparation on the fauna of the Vicksburg group. All the species thus far found are also present in the overlying Mint Spring marl member of the Marianna limestone.

Fossil leaves have been found at several localities, but the state of preservation has been so poor that they could not be collected. Silicified wood is common on the surface of the outcrop of the formation and has been found in place in the formation at some localities. Several specimens of this wood were submitted to R. W. Brown, who states (written communication, Mar. 11, and Apr. 10, 1936) that all of these possibly belong to the persimmon family, *Diospyros.*

Stratigraphic relations.—The Forest Hill sand appears to rest conformably on the underlying Yazoo clay. This relationship has been observed on Pearl River (pp. 67–68), on the Brandon-Fannin road (p. 71), and in several auger holes that have penetrated the contact. In these holes the sequence of beds is finely laminated sand grading downward into blue-gray sandy clay underlain by blue noncalcareous clay which in turn is underlain by greenish-blue calcareous clay. The contact of the two formations should probably be placed at the top of the blue noncalcareous clay, for on the outcrop this clay contains prints of a Jackson species of *Leda.*

In eastern Mississippi the Yazoo clay is overlain by the Red Bluff clay. The fossils as well as the lithologic character of the Yazoo and the Red Bluff are quite different, and the contact may mark a break in deposition. The Forest Hill sand in that part of the State rests conformably on the Red Bluff clay and it is generally believed, but not proved, that the Red Bluff merges laterally westward into the lower part of the Forest Hill sand of western Mississippi. The Red Bluff clay has not been recognized west of Smith County.

As indicated above, the Yazoo clay and Forest Hill sand seem to be conformable in the Jackson area, but the writer suggests that the possible break in deposition between the Yazoo and Red Bluff clays, which is best exposed at Hiwannee on Chickasawhay River, may be represented somewhere in the section in the Jackson area. As the uppermost part of the Yazoo clay contains Jackson, not Red Bluff fossils, the break in deposition, if it is present at all, is somewhere in the lower part of the Forest Hill sand. A possible horizon worth further investigation is the carbonaceous bed near the base of the formation, well exposed in the gullies in sec. 26, T. 5 N., R. 1 W., (see p. 67). The writer, however, recognizes the possibility that sedimentation may have been continuous in western Mississippi from Yazoo time through Red Bluff and Forest Hill time because of the great amount of material available for formation of the Forest Hill delta (see Origin, below), but most of the disconformities thus far investigated in Mississippi have proved widespread, so for the time being he favors the idea that the break in deposition may be in the lower part of the Forest Hill. If this hypothesis is true it follows that the Forest Hill is a compound formation including material at the base that should be considered Jackson in age as Mellen (1940, p. 16) suggests, and material higher in the formation that is Oligocene. Until widespread stratigraphic studies are made and the Yazoo and Red Bluff contact is traced westward carefully the entire sand sequence between the Yazoo clay and the Mint Spring marl member of the Marianna limestone can best be called the Forest Hill sand and treated as a formation of Oligocene age, recognizing that the basal part may be Eocene.

The upper fossiliferous beds of the Forest Hill sand have been considered by all previous writers except Mellen to be a part of the Mint Spring marl member of the Marianna limestone because the rather scarce fossils are all Mint Spring species. The writer considers that these beds should logically be included in the Forest Hill sand, or rather that the Mint Spring marl member should be restricted to the highly fossiliferous sands described in the next section of this report, because the disconformity separating the two fossiliferous beds has been recognized at the same horizon from Haynes Bluff in Warren County, Miss., to St. Stephens Bluff, Washington County, Ala. Although the time interval represented by this disconformity is admittedly short, the disconformity represents a geologic event significant enough to warrant placing a stratigraphic contact at the break.

Origin.—The Forest Hill sand is interpreted as consisting at least in part of a great delta complex deposited at the end of Jackson and the beginning of Oligocene time. Most exposures show nearly horizontal thin-bedded and laminated, very fine-grained sand with subordinate amounts of gray clay. These beds appear to have been deposited as topset beds of delta distributaries and in adjacent lagoons and tidal lakes. At a few exposures, notably those on Lime Creek in sec. 15, T. 4 N., R. 1 E., Rankin County, steeply dipping beds are well exposed beneath horizontal beds. At the top of the formation are beds of fossiliferous clay, probably deposited in lagoons at the sides of the distributaries. Beds of slightly calcareous clay have been seen at a few places in lower parts of the formation and if these could be found in fresh exposures they, too, might yield fossil shells. Beds of lignite thickest near the top of the formation but present locally at lower levels probably represent times when deposition of the formation exceeded subsidence to such an extent that swamps could form and support a growth of vegetation. This vegetation probably checked the flow of water and permitted subsidence to exceed deposition, so that the swamp conditions were of only short duration and were succeeded by rapid deposition of sand. Forest Hill deposition was ended by a downwarping of the area which caused a marine transgression initiating deposition of the Marianna limestone.

Physiographic expression.—The most conspicuous relief feature in the Jackson area is the scarp that marks the inner edge of the Forest Hill cuesta. The face of this cuesta overlooks the Jackson Prairie belt as a prominent asymmetric ridge that corresponds roughly with the line of outcrop of the base of the Forest Hill sand except at places where surficial deposits lie immediately up dip from the Forest Hill sand; at these places the scarp is formed by the surficial sands. The topography of the belt of outcrop of the Forest Hill sand is rough and might be characterized as being in the stage of early maturity in which steep slopes are more common than flat areas. In general the steepest slopes are near the cuesta face. The topography of the upper part of the formation merges into slightly more subdued topography of the Vicksburg group with no noticeable boundary.

An exception to the facts presented above is the topography of the synclinal area in T. 7 N., R. 1 E, Madison County. Here the topography was originally a gently undulating plain indistinguishable from the Jackson Prairie to the south, east, and north. Rapid erosion of Limekiln Creek in very recent time has caused intense dissection of the upper part of the Forest Hill sand, with many instances of capture by Limekiln Creek of older streams that drained southeast into Pearl River. Many of the valleys follow land lines and make right-angle bends at land corners suggesting that some of the erosion may have been started about 1821 by survey parties in the region. Remnants of the older land surface are preserved on isolated hills.

VICKSBURG GROUP

Conrad (1847, pp. 280, 281) named the Vicksburg group in 1847 from the fossiliferous exposures of limestone at Vicksburg, Miss. In 1855 he (1855, pp. 257, 258) divided the sequence of deposits in the eastern Gulf region into "Newer Eocene, Vicksburg * * * Older Eocene, Jackson * * * Older Eocene, Claiborne" in descending order. Hilgard (1860, pp. 138–147, map) in mapping the outcrop of the Vicksburg group across the State was remarkably accurate. His description of the lithologic character of the group is exceptionally clear and his definition of the group stands today with few changes.

In the present report the Vicksburg group is divided into the Marianna limestone including the Mint Spring marl member at its base, and the Byram formation, including as members the Glendon limestone, middle marl, and the Bucatunna clay. Until 1941 the classification of the Vicksburg group accepted by the Geological Survey included the Forest Hill sand and the Chickasawhay limestone. Recent stratigraphic and faunal studies by F. Stearns MacNeil, however, indicate that it is preferable to restrict the Vicksburg group to the predominantly calcareous formations characteristically exposed at Vicksburg, Miss. The widespread disconformity at the base separates the underlying Oligocene Forest Hill sand and Red Bluff clay, and an overlapping unconformity at the top separates the group from the Chickasawhay limestone.

Mornhinveg and Garrett (1935, pp. 1645–1667) made a careful study of the Vicksburg group at the type locality, where they defined the Mint Spring marl, the Marianna(?) limestone, the Glendon(?) limestone, and the Byram marl. In the present paper the writer includes the lower part of their Mint Spring in the upper part of the Forest Hill sand and includes in the Byram most of their Marianna(?), Glendon(?), Byram and Catahoula. The reasons for this are discussed under each formation.

MARIANNA LIMESTONE (MINT SPRING MARL MEMBER)

Name.—Cooke (1918, pp. 195–196) suggested the name Mint Spring marl member for the western Mississippi equivalent of the "chimney rock" facies of the Marianna limestone. His statement follows:

> The "chimney rock" facies of the Marianna limestone is replaced in western Mississippi by sands and shell marls for which the name Mint Spring calcareous marl is here proposed. The name is derived from Mint Spring Bayou, a small stream entering Centennial Lake just south of the National Cemetery at Vicksburg. The strata to which the name is applied are exposed beneath a waterfall in the lower course of the stream.

Mornhinveg and Garrett (1935, p. 1659) defined the Mint Spring marl by placing the upper limit

> at the first limestone ledge, and the lower at the last fossiliferous bed. Between these limits are included 20–25 feet of marine strata, grading from sparingly fossiliferous lignitic sands and clays in the lower portion to sandy fossiliferous marls in the upper.

As explained above, the lower part of their Mint Spring is here included in the upper part of the Forest Hill sand. This reduces the thickness of the Mint Spring marl member to about 10 feet.

Mellen (1940, p. 26) considers the Mint Spring marl a facies of the Glendon member of his Vicksburg formation.

Areal distribution.—The Mint Spring marl member of the Marianna limestone crops out in a very narrow band above the Forest Hill sand from its type locality in Vicksburg, Warren County, northward into Yazoo County, thence east-southeastward through Warren, Hinds, Rankin, Smith, Jasper, and Wayne Counties. In the Jackson area outliers are present in the southwestern part of Madison County. The Mint Spring has not been formally recognized east of the Chickasawhay River near Boyce, Wayne County, but equivalent beds at the base of the Marianna limestone have been recognized as far east as St. Stephens Bluff, Washington County, Ala.

In the area mapped in this report (pls. 1–4) the member is present at several outcrops in secs. 9, 10, 16, 20, and 21, T. 7 N., R. 1 E., Madison County; near Forest Hill School in secs. 15 and 22, T. 5 N., R. 1 W., Hinds County; and as a continuous belt, except where it is covered by alluvium and other surficial deposits, from sec. 31, T. 5 N., R. 1 E., Hinds County, through T. 4 N., Rs. 1 and 2 E., T. 5 N., Rs. 2 and 3 E., T. 6 N., R. 3 E., and T. 5 N., R. 4 E., Rankin County. Outliers are present to the east in T. 5 N., R. 5 E., Rankin County. Although the member is thin, it is an important stratigraphic marker and in general the width of the belt of outcrop is exaggerated on the map.

Lithologic character.—The Mint Spring marl member of the Marianna limestone, where unweathered, consists of blue-gray glauconitic calcareous sand containing abundant fossil shells; in the upper part it contains less sand and more lime, approaching lithologically a true marl. Overlying the marl proper is a concretionary, very sandy limestone, 1 to 3 feet thick, containing a few phosphatic molds. F. S. MacNeil (oral communication) believes this limestone is the western equivalent of the Marianna limestone, but for simplicity it is included in the Mint Spring marl member in this report. The member itself weathers to somewhat calcareous rusty-brown sand that contains prints of fossil shells and much manganiferous limonite. Upon more intense weathering the member becomes a ferruginous sandstone containing no vestige of its fossils.

One of the best exposures of the Mint Spring marl member of the Marianna limestone, on a branch of Lime Creek, at a waterfall in the SW¼ SW¼ SE¼ sec. 15, T. 4 N., R. 1 E., Rankin County, is described on page 69. Here the formation includes 6 feet of very glauconitic fossiliferous sand overlain by 3 feet of the concretionary glauconitic, sandy limestone. The disconformity at the base of the member (fig. 6) and the diastem(?) between the Mint Spring marl member and the Glendon limestone member of the Byram formation are both well exposed here.

The most prolific fossil-collecting locality known in the belt of outcrop of the Mint Spring marl member is on another branch of Lime Creek, in the SE¼SW¼NW¼ sec. 22, T. 4 N., R. 1 E., Rankin County.

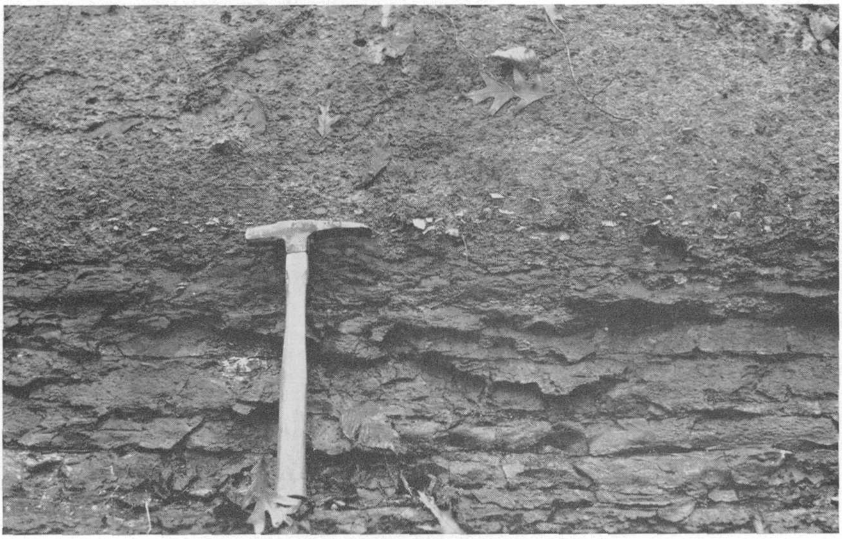

FIGURE 6.—Disconformable contact of the Mint Spring marl member of the Marianna limestone on the uppermost marine clay bed of the Forest Hill sand. Note abundant shells of *Pecten poulsoni* at the base of the Mint Spring. Left bank of branch of Lime Creek, sec. 15, T. 4 N., R. 1 E., Rankin County.

About 6 feet of fossiliferous blue-gray glauconitic sand of the Mint Spring rests disconformably on black lignitic clay of the Forest Hill sand that is perforated by numerous borings filled with sand from above. Underlying the clay is 8 inches of fossiliferous gray sand containing water-worn fossil shells, underlain by 1 foot of black carbonaceous clay, in turn underlain by 4 feet of blue-gray unfossiliferous sand, which rests on 10 feet of characteristic Forest Hill yellow and gray sand and clay containing comminuted plant remains. The altitude of the contact of the Forest Hill sand and the Mint Spring marl member is 272.0 feet.

On a third branch of Lime Creek in the NE¼SE¼NW¼ sec. 22 the following section is poorly exposed:

Section in branch of Lime Creek, sec. 22, T. 4 N., R. 1 E., Rankin County

	Feet
Marianna limestone (Mint Spring marl member):	
Limestone, hard, nodular, sandy, containing phosphatic molds; grades downward into ferruginous, sandy, limy marl	2.5
Marl, blue, glauconitic, very fossiliferous, sandy	8
Disconformity (altitude 271.7 feet).	
Forest Hill sand:	
Clay, black, sandy, containing scattered fossils	2
Sand, gray, thin-bedded carbonaceous fine-grained	6
	18.5

The upper part of the Mint Spring marl member of the Marianna limestone is well exposed at Hemphill Bluff on Pearl River, in sec. 20, T. 4 N., R. 1 E., Rankin County, and the section exposed there is described on pages 84 and 85.

The following descriptions of the upper part of the Mint Spring marl member were written on a trip down the Pearl River on August 3, 1939. From Hemphill Bluff for three-quarters of a mile all exposures are of alluvium. Near the center of the NW¼ sec. 20, T. 4 N., R. 1 E., on the left bank the following section is exposed:

Section on left bank Pearl River, at bend to northwest, sec. 20, T. 4 N., R. 1 E., Rankin County

	Feet
Byram formation, Glendon limestone member: Marl, finely glauconitic, blue-gray, weathering to cream; indurated layer about 6 inches thick at top	3
Marianna limestone, Mint Spring marl member:	
Marl, hard, concretionary, ferruginous, sandy, glauconitic	5
Sand, blue-green, fossiliferous, fine-grained	2.5
	10.5

This exposure is continuous for about 600 feet on the left bank and the beds rise 3 feet downstream (northwest). The lower material exposed at the northwest end of the exposure is like the basal bed in the preceding section and is near the base of the member, but the Forest Hill sand is not exposed. On the right bank in the NW¼NW¼NW¼ sec. 20, the concretionary sandy marl is exposed for a distance of about 500 feet. All exposures below this point are of the Byram formation.

Slightly weathered Mint Spring marl member is described in the section at Forest Hill School (pp. 64–65). The ferruginous sandstone that appears to be about the end product of weathering of the member is well exposed near the top of the railroad cut at Rankin, in the N½NE¼SE¼ sec. 8, T. 5 N., R. 4 E., Rankin County.

Montmorillonitic clay, possibly a highly altered bentonite, has been observed in the Mint Spring marl member at several places near

Brandon. A thin bed is exposed in gullies at the side of the old Brandon-Jackson highway in the SW¼NW¼SE¼ sec. 7, T. 5 N., R. 3 E., Rankin County, about 5 to 8 feet above the contact of the Mint Spring and the Forest Hill sand. There has been much slumping here because of intense weathering of the Mint Spring marl member to gray and chocolate-brown medium-grained sand and clay, so that the exact height of the bed above the contact is not known.

At milepost 77 on the railroad between Brandon and Rankin near the center of sec. 7, T. 5 N., R. 4 E., Rankin County, the following section is exposed:

Section on railroad at milepost 77, Rankin County

	Feet
Byram formation, Glendon limestone member: Limestone in irregularly shaped blocks and brown residual clay	11
Marianna limestone, Mint Spring marl member:	
Clay, brown and gray, glauconitic, sandy	3
Montmorillonite (bentonite?)	1
Sand, glauconitic, fine-grained, brown	1
Disconformity (altitude 424.5 feet).	
Forest Hill sand: Clay, thin-bedded, gray, containing comminuted plant remains, interbedded with laminated gray fine-grained sand	11
	27

Thickness.—The thinnest section of Mint Spring marl member of the Marianna limestone seen in the area is the 5-foot section measured in the railroad cut at milepost 77; here the blocks of Glendon limestone member of the Byram formation may have slipped downhill covering upper beds of the Mint Spring. Throughout most of the Jackson area the Mint Spring is about 10 feet thick. In general the member is somewhat thicker down the dip than it is in outliers; in T. 7 N., R. 1 E., Madison County, the thickness rarely exceeds 6 feet. Cooke (1923, p. 2) indicates that a wedge of Marianna limestone ("chimney rock") extends as far west as Pearl River, but the writer did not recognize it during his field work in the area.

Fossil content.—The Mint Spring marl member of the Marianna limestone is very rich in fossil mollusks and these are now being studied critically by F. Stearns MacNeil. His forthcoming monograph on the fauna of the Vicksburg group will contain so many new species that it is better not to list known species in the present paper. At most exposures *Pecten poulsoni* is common and is a good guide fossil. *Lepidocyclina mantelli* is present at some exposures and it also is a restricted species suitable for use as a guide fossil. Both species, however, are also present in the "chimney rock" facies of the Marianna limestone.

The best collecting localities in the Jackson area for Mint Spring species are on the many branches of Lime Creek in secs. 15 and 22, T. 4 N., R. 1 E., Rankin County.

Stratigraphic relations.—The Mint Spring marl member of the Marianna limestone rests disconformably on the Forest Hill sand from the Mississippi River eastward into Alabama. In the western part of Mississippi and in the Jackson area the Mint Spring is overlain directly by alternating limestone and marl beds of the Glendon limestone member of the Byram formation. In eastern Mississippi the Mint Spring grades upward into the "chimney rock" facies of the Marianna limestone.

At some outcrops in the Jackson area there is evidence of a break in deposition, possibly a diastem, between the Mint Spring marl member and the Glendon limestone member of the Byram formation. At others no break could be detected. It is possible that deposition of the Marianna proceeded very slowly after deposition of the Mint Spring and that the "chimney rock" of eastern Mississippi and Alabama may be represented by the nodular layer of concretionary calcareous sandstone at the top of the Mint Spring marl member.

Origin.—The Mint Spring marl member of the Marianna limestone represents the basal sand deposited by the transgressing Marianna sea following a sudden down warping that ended Forest Hill time. It seems likely that in western Mississippi deposition was very slow during later Marianna time, or there may have been a local uplift at the end of Marianna time that removed the "chimney rock." The writer favors the idea that the "chimney rock" was never deposited in western Mississippi but that the time interval is represented by the sandstone at the top of the Mint Spring marl member.

Physiographic expression.—The Mint Spring marl member of the Marianna limestone is so thin that in the upland it is merely in the transition zone from the highly dissected hills of the Forest Hill sand to the more gently rolling country of the Byram formation. On streams east of Byram, however, the indurated, concretionary layer at the top of the formation forms waterfalls. On the Pearl River this layer forms low vertical cliffs in the banks.

BYRAM FORMATION

Name.—Casey (1901, pp. 517–518) first used the name Byram in a stratigraphic sense for the fossiliferous marl exposed on the right bank of the Pearl River, at Byram, Hinds County, Miss. He was mistaken in placing it below the limestone exposed at Vicksburg. Cooke (1918, pp. 196, 197) formally proposed the name Byram calcareous marl in 1918. Further details about the formation were included in papers published by Cooke (1922, pp. 79–85; 1923, p. 3).

In these papers Cooke states that most of the shells collected and described by Conrad (1848, pp. 111–134) came from the Byram marl at Vicksburg, Miss., and that the Byram might be considered the type formation of the Vicksburg group. Mornhinveg and Garrett (1935, p. 1659) disagree and state that Conrad's

> interest was first aroused by the limestone, the "Vicksburg limestone", so conspicuously exposed in the bluffs. Thus, this "Vicksburg limestone" more properly deserves to be considered the type formation of the Vicksburg, if there be any, than the Byram marl, as Cooke advocates, although Conrad apparently collected many of his Vicksburg fossils from the Byram.

As this limestone is considered a member of the Byram in the present paper, the two views are compatible. In 1941, at the suggestion of F. Stearns MacNeil, the Geological Survey changed the name to Byram formation and included within it besides the middle marl member typically exposed at Byram, the Glendon limestone member below, and the Bucatunna clay member above.

Glendon limestone member.—In 1918 Cooke (p. 195) suggested the name Glendon limestone member of the Marianna limestone for "a series of ledges of hard, partly crystalline, yellowish or pinkish limestone interbedded with softer strata of impure limestone." In a later paper (Cooke, 1923, p. 3), he raised the Glendon to formational rank partly because of a miscorrelation of the cherty beds in Georgia now known as the Flint River formation. Recent work by F. Stearns MacNeil (oral communication) has shown that the Glendon limestone member at the type locality, a siding on the Southern Railway in Clarke County, Ala., is more closely related faunally and lithologically to the Byram than to the Marianna limestone. The typical Glendon is known only in western Alabama and eastern Mississippi where it occurs as crystalline ledges that weather to a "horsebone rock". Cooke extended the name to western Mississippi for the limestone and marlstone and interbedded marls between the Mint Spring marl member of the Marianna limestone and the middle marl member of the Byram. As this part of the Vicksburg group is a distinct lithologic unit in the Jackson area, the name Glendon is retained for the interbedded hard and soft marls and limestones below the middle marl member, and these beds constitute the Glendon limestone member of the Byram formation.

Bucatunna clay member.—While making structural studies in Wayne County, Miss., in 1931, Tom McGlothlin (oral communication) recognized a thickened section of rocks between the middle marl member of the Byram formation and the Catahoula sandstone and used the names Bucatunna clay and Chickasawhay limestone for these intercalated beds. Blanpied (Blanpied, Oldham, and Alexander, 1934, p. 13) adopted these field names in the following statement:

> The name Bucatunna from the type locality on Bucatunna Creek is applied to a sequence of bentonitic clays, bentonite, and cross bedded sands which rest upon the rocks of the Vicksburg group with distinct unconformity.

Cooke (1935, pp. 1165–1170) suggested that the Bucatunna and Chickasawhay be considered members of the Byram because they have previously been mapped as a part of the Byram and had been so described (but not named) in the Geology of Alabama (Cooke, 1926, pp. 287–294); furthermore he doubted the presence of a great unconformity at the base of the Bucatunna. Hughes (1938, p. 16) stated that the Bucatunna overlaps the Byram, Glendon and Marianna, and in places rests on Forest Hill sand in Smith County, Miss.

MacNeil in his work in Wayne County found a distinct unconformity between the Bucatunna clay member and the Chickasawhay limestone expressed in part by the Chickasawhay overlapping all other Oligocene formations. The Chickasawhay is, therefore, considered a formation separate from the Vicksburg group because of this disconformity and because of a marked difference in fauna. The Chickasawhay has not been recognized in western Mississippi, although MacNeil has offered the suggestion that sand beds between the Bucatunna clay member and the Catahoula sandstone may be the western equivalent of the Chickasawhay. In the present paper these beds are included in the Bucatunna because the evidence of their Chickasawhay age is as yet too scanty. Accordingly, in the present classification used by the U. S. Geological Survey, the Bucatunna clay is considered the uppermost member of the Byram formation.

Areal distribution.—The Byram formation, including its named members is present in a belt across Mississippi from Warren County and the southern part of Yazoo County on the west to Wayne County on the east. It is present in western and central Alabama and has been doubtfully identified in Florida.

Within the area mapped in this report (pls. 1, 3, and 4) the Byram formation is exposed in secs. 9, 10, 16, 20 and 21, T. 7 N., R. 1. E., Madison County; in a belt, interrupted only by surficial deposits, extending from T. 4 N., R. 1 W., Hinds County, eastward in Rankin County through the middle of T. 4 N., R. 1 E.; in the northern part of T. 4 N., R. 2 E.; in the eastern part of T. 5 N., R. 2 E.; over much of T. 5 N., R. 3 E., except the central part; and in the southern parts of T. 5 N., Rs. 4 and 5 E.

Lithologic character.—The Glendon limestone member of the Byram formation consists of alternating beds of marl and marlstone or limestone. At the top of the member is a layer of hard crystalline limestone from 1 to 3 feet thick. The member weathers to a brown clay, containing at many places white, waxy clay that may be beidellite or some other mineral of the beidellite-montmorillonite series; this clay may be the product of replacement of limestone as described by Ross and Stephenson (1939, pp. 393–397). Manganese stains are common in the joints of this clay. Some of the clay is plainly residual from the very clayey limestone of the marl beds (fig. 7). Thin,

FIGURE 7.—Residual clay of the Glendon limestone member of the Byram formation containing a small block of partly weathered limestone. Gully near public road NE¼SW¼ sec. 16, T. 7 N., R. 1 E., Madison County.

noncommercial beds of bentonite have been seen at a few places interstratified with the marl. Some of the beds contain considerable glauconite, some are remarkably free of this mineral. Pyrite is a common constituent of the unweathered marl and limestone; most of the slightly and highly weathered beds contain much limonite that probably has formed from the weathering of the pyrite and glauconite. Fossil shells are rare in the member excepting the characteristic *Pecten byramensis* (somewhat resembling and generally confused with *Pecten poulsoni*, but having shouldered ribs) and *Lepidocyclina supera* which are common; molds of the interior and exterior of shells that have been leached from the rock are common in some of the harder layers.

The middle marl member of the Byram formation is much more sandy and more glauconitic than the Glendon limestone member. Thin limestone beds are common at irregular intervals, but most of this part of the formation consists of relatively unconsolidated very sandy marl. These marl beds weather to brownish-red clayey sand and sandy clay. Fossil shells are very abundant in the unit.

In the Jackson area the Bucatunna clay member consists largely of black silty, somewhat carbonaceous clay that commonly weathers to chocolate-colored shaly clay. More intense weathering produces gray plastic sandy clay. The upper middle part of the member contains discontinuous beds of dark-gray silty, clayey, glauconitic sand that contains widely scattered shells; this material has not been recognized in weathered beds. The upper part of the member consists of thin-bedded very fine micaceous sand that contains interbedded chocolate-colored clay layers in the lower part and merges upward into more massive sand beds. This upper part of the member may represent the western equivalent of the Chickasawhay limestone of eastern Mississippi.

The entire section of the Byram formation cannot be seen at any one place, but the section may be pieced together quite accurately from a number of exposures. All but the upper few feet of the Glendon limestone member is exposed at the Hemphill Bluff on the left bank of the Pearl River in the NE¼NE¼ sec. 20, T. 4 N., R. 1 E., Rankin County.

Section at Hemphill Bluff, left bank of the Pearl River, Rankin County

	Feet
Byram formation:	
Undifferentiated clay, brown, residual from limestone and marl; to top of bluff	8.5
Glendon limestone member:	
Marlstone, hard, flaky	1.8
Marl, soft, slightly glauconitic, cream-colored	1.2
Marlstone, compact; very flaky on surface	1.5
Marl, pink, medium glauconitic; nearly continuous layer of gypsum near middle	.8
Marl, gray, medium glauconitic	.6
Marl, pink medium glauconitic	.2
Shell bed made up largely of *Lepidocyclina supera* and *Pecten byramensis*	.3
Marl, soft, very slightly glauconitic, cream-colored	.4
Marlstone, discontinuous, hard; less glauconitic than underlying bed	.8
Marl, soft, slightly more glauconitic than underlying marlstone; contains small lens of gypsum	.8
Marlstone, very light-gray to white, hard; glauconite grains are common but the rock is not highly glauconitic	1.5

Section at Hemphill Bluff, left bank of the Pearl River, Rankin County—Con.

	Feet
Byram formation—Continued	
Glendon limestone member—Continued	
Marl, blue, weathering to dark grayish-tan, slightly glauconitic, clayey	1.0
Marl, soft, tan and cream-colored, slightly glauconitic, containing many borings; at base is a 1-inch shell bed of *Lepidocyclina supera*	1.1
Marlstone, discontinuous, hard, glauconitic, slightly sandy	1.8
Marl similar to underlying bed but containing more glauconite	.7
Marl, cream-colored, very slightly sandy, very slightly glauconitic; somewhat indurated in upper part	1.8
Marianna limestone(?):	
Hard knotted glauconitic ferruginous sandstone; upper few inches slightly calcareous	5.8
Fine glauconitic slightly ferruginous quartz sand; contains a few shell fragments	.6
Marianna limestone, Mint Spring marl member:	
Marl, cream-colored, glauconitic, like underlying bed but leached; contains borings filled with overlying sand	.5
Marl, light blue-gray, glauconitic, sandy, containing soft shells	2.3
Clay, very dark-green, waxy, containing shells, probably bentonite	.9
Sand, fine, light-brown, glauconitic, containing soft decalcified shells; lower part from pit and auger hole	5.3
Sand, highly ferruginous, fine; in auger hole	.5
Marl, blue-gray, sandy, highly glauconitic, containing shells impenetrable to auger	.5
	41.2

The weathered upper part of this section probably includes the top of the Glendon limestone member; the bottom bed reached in the auger hole is the basal bed of the Mint Spring marl member of Marianna—Forest Hill sand is probably less than a foot deeper.

The upper part of the Glendon limestone member is well exposed in a railroad cut, $1\frac{1}{2}$ miles southeast of Plain, in the $E\frac{1}{2}SW\frac{1}{4}NE\frac{1}{4}$ sec. 12, T. 4 N., R. 1 E., Rankin County, where the following section is exposed:

Section in railroad cut, $1\frac{1}{2}$ miles southeast of Plain

	Feet
Byram formation:	
Middle marl member:	
22. White chalk, clay, and calcareous concretions (highly weathered material)	2.3
21. Shell bed	.7
20. Clay, iron-stained, calcareous	.6
19. Shell bed	.6
18. Marl, light-yellow, soft	1.2
17. Shell bed	.5
16. Marlstone, soft, yellow, glauconitic	1.6

Section in railroad cut, 1½ miles southeast of Plain—Continued

	Feet
Byram formation—Continued	
Glendon limestone member:	
15. Limestone, hard, white; very irregular base	1.8
14. Marl, soft, white	.5
13. Limestone, hard, white, glauconitic	.5
12. Marl, medium hard, cream-colored, glauconitic, fossiliferous	1.6
11. Limestone, hard, gray	.8
10. Marl, soft, yellow, glauconitic	.3
9. Limestone, hard, gray, glauconitic	.7
8. Marl, soft, cream-colored, fossiliferous, glauconitic	.5
7. Limestone, hard, white to cream-colored, glauconitic, fossiliferous; very irregular base	1.0
6. Clay, soft, yellow, highly glauconitic, calcareous, containing rich shell bed 6 inches above base	1.7
5. Limestone, hard, slabby, fossiliferous, glauconitic	.9
4. Marl, soft, cream-colored, glauconitic, fossiliferous	.8
3. Limestone, hard, white, fossiliferous; glauconite-filled borings	.9
2. Marl, soft, cream-colored; contains no glauconite; contains many soft shells	1.2
1. Limestone, hard, cream-colored, fossiliferous, containing thin lenses of cream-colored marly clay	1.5
	22.2

Approximately the same section is exposed at Robinson quarry in the NE¼NE¼SW¼ sec. 19, T. 5 N., R. 4 E., Rankin County, except that some of the limestone and marl beds differ in thickness from those in the railroad cut southeast of Plain. The hard limestone bed at the top of the Glendon limestone member is exposed at the top of the quarry. Beds 7 and 15 in the section described above are easily recognized throughout much of the Jackson area and are both present in Robinson quarry, but the interval between them there is somewhat greater than in the railroad cut: in the quarry the difference in altitude of the tops of the two beds is 9.2 feet, in the railroad cut 6.7 feet. About 22 feet of alternating limestone and marl is exposed in the quarry.

The upper part of this section is exposed in the bank of Richland Creek in the NW¼SW¼NW¼ sec. 3, T. 4 N., R. 2 E., Rankin County. Here bed 7 in the section described above forms a wide platform. The top bed of the Glendon limestone member (bed 15) is exposed in the creek bank only at the southeastern end of the exposure.

In 1931 M. A. Pentz collected some exceptionally pure halloysite from a marl bed between two limestone layers in a road cut in the SE¼NE¼NW¼ sec. 23, T. 5 N., R. 3 E., Rankin County. Since that time this exposure has disappeared, partly by disintegration of the limestone and partly by filling of the road-side ditch. The deposit consisted of a lens of manganese-coated halloysite an inch or so thick in the midst of highly weathered clay underlain and overlain by clay residual from limestone.

The middle marl member of the Byram formation is nowhere completely exposed, but many outcrops along Pearl River have been pieced together to make up the following composite section. Localities at which parts of the section crop out are given after the section.

Composite section of the middle marl member of the Byram formation on the Pearl River

	Feet
Byram formation:	
Bucatunna clay member: 12. Sand, thinly laminated, glauconitic, containing a little dark-gray clay	1.0
Middle marl member:	
11. Sand, blue-gray, fossiliferous, glauconitic	4.5
10. Limestone, hard, concretionary, sandy	1.6
9. Sand, blue-gray, fossiliferous, glauconitic, calcareous; weathers to light-brown	3.7
8. Limestone, cream-colored, soft but concretionary; contains less sand than underlying beds; pink in places	1.6
7. Marl, soft, very fossiliferous	4.5
6. Limestone, sandy, glauconitic	1.0
5. Marl, glauconitic, sandy, very fossiliferous; lowest bed in which *Scapharca lesueuri* could be found	3.4
4. Limestone, sandy, glauconitic; changes laterally downstream to a discontinuous layer of concretions; may be absent locally	2.0
3. Sand, blue, highly glauconitic, richly fossiliferous, medium-grained	1.8
2. Sand, compact, soft, glauconitic, fossiliferous, fine-grained	4.5
Glendon limestone member: 1. Limestone, hard, crystalline, glauconitic	2.3
	31.9

An exposure about one-tenth of a mile long on the right bank of the Pearl River in the SE¼SW¼NE¼ sec. 19, T. 4 N., R. 1 E., Hinds County, includes beds 1 to 4. The top of the Glendon limestone member passes under water level about midway of the exposure. On the opposite side of the river at a sharp bend to the west is another exposure about one-tenth of a mile long in the N½NW¼SE¼ sec. 19 at the west end of which the top of the Glendon again rises above water level, showing a slight reversal in dip. Beds 1 to 6 are exposed here. About 800 feet downstream on the same bank at a bend to the north is another exposure in which the Glendon is again below water level and beds 3 to 6 are exposed. This exposure continues on the left bank for about one-fifth of a mile to the north edge of the NE¼SE¼ NW¼ sec. 19, where, at the beginning of a bend to the west, the Glendon has risen to 4 feet above water level. Here the limestone (bed 1) and the soft sand (bed 2) and 2 feet of marl under the hard layer (1) are exposed.

At the sharp bend to the west in the SE¼NE¼NW¼ sec. 19 the top of the Glendon limestone member rises to 5.3 feet above water level and because of the bend in the river appears to form a gentle arch (fig. 8). The exposure continues for one-eighth of a mile downstream and near the western end of the exposure the Glendon member passes below water level and does not reappear at any point downstream. At the

FIGURE 8.—Glendon limestone member overlain by middle marl member of the Byram formation in a small arch on the right bank of the Pearl River, half a mile east of Byram, sec. 19, T. 4 N., R. 1 E., Hinds County.

point where the Glendon disappears below water level the prominent layer of sandy limestone, bed 4, is present only as two small concretionary masses in a thick bed of glauconitic sand. In this long exposure on the right bank beds 1 to 6 of the composite section are exposed.

The type locality of the Byram formation (fig. 9) is on the right bank of the Pearl River underneath a suspension bridge in the S½NW¼NW¼ sec. 19, T. 4 N., R. 1 E., Hinds County. Here beds 5 to 8 of the section are exposed. Most of the fossil collections from the Byram have been made from richly fossiliferous, glauconitic, sandy marl designated bed 7 in the composite section. There is a nearly continuous exposure on the right bank below Byram for one-fourth of a mile, a short exposure on the left bank, and then another continuous exposure of about half a mile on the right bank. The dip is continuously downstream to the south and beds 8 to 11 pass under water in succession. Beds 10 to 12 are exposed at the last exposure in this stretch of the river in the NW¼NW¼NW¼ sec. 30, T. 4 N., R. 1 E., Hinds County. So far as could be determined the contact of the middle marl member and the Bucatunna clay member of the Byram is gradational.

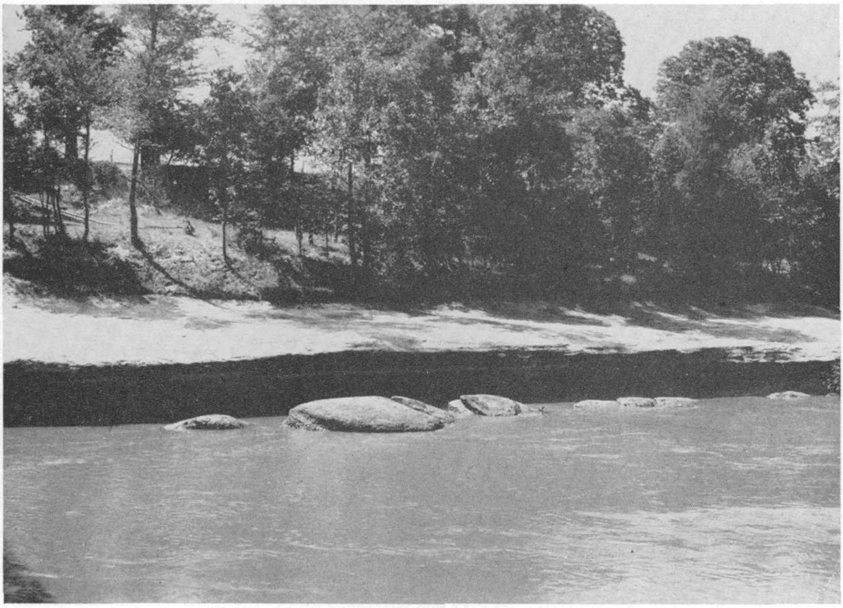

FIGURE 9.—Type locality of the Byram formation on the right bank of the Pearl River at Byram, sec. 19, T. 4 N., R. 1 E., Hinds County.

In his unpublished notes on the Jackson-Vicksburg area O. B. Hopkins mentions clay on the left bank of the Pearl River a short distance above Wansley Bend, which would be somewhere in section 30. This clay is probably a part of the Bucatunna clay member, but the author could not find the exposure.

At the north end of Wansley Bend in the S½SW¼ sec. 30, nearly the entire section of the middle marl member of the Byram formation is exposed. It is very probable that there is a sharp flexure or fault just north of the bend that causes a reversal in dip. The exact strike of the beds at this part of the bend has not been determined, but the apparent westerly dip is 150 feet to the mile; as the dip here is probably about west-northwest, the true rate of dip is much greater. The top bed of the Glendon limestone member was not exposed in 1939, but it is probably present just below water level or concealed by alluvium at the eastern end of the exposure. The section exposed at the northeastern end of the bend on August 7, 1939, is described below:

Section on left bank Pearl River at northeast end of Wansley Bend

	Feet
Byram formation, middle marl member:	
Marl	6.0
Marlstone	0.7
Marl	1.0
Marlstone	0.7
Marl	2.8
Concretionary layer	1.0
Marl, very fossiliferous	4.5
Sandstone, soft, calcareous, glauconitic, fossiliferous, probably same as indurated layer at top of bluff at Byram	0.9
Sand, very fine-grained, glauconitic	8.7
	26.3

Just west of this exposure Bucatunna clay member is exposed at water level. Half a mile west of the bend described above very ferruginous siltstone of the Catahoula sandstone is exposed as boulders in the river and in the bank of the river, but the siltstone was not seen in place. It seems certain, however, that the bed is nearby and that there has been only minor slumping. Beyond these boulders there is a reversal in dip which again brings the Bucatunna clay member above water-level and at the western end of Wansley Bend in the NW¼ NE¼NW¼ sec. 36, T. 4 N., R. 1 W., Hinds County, west of the mapped area 8 feet of brown blocky weathered Bucatunna clay member stained with yellow iron oxide is exposed. Halfway down the east-southeast reach of the river in sec. 36, west of the Florence quadrangle is the mouth of a small creek. About 300 feet up this small creek is an exposure of 5 feet of dark-gray very fine, sandy, micaceous clay containing comminuted plant remains. This clay is Bucatunna in the unweathered state; after weathering the clay becomes brown giving rise to the usual field name of "chocolate clay."

At the bend in the river to the northeast in the NE¼SW¼NE¼ sec. 36 on the right bank just west of the Florence quadrangle there was on May 15, 1936, an exposure of 5 feet of fossiliferous fine-grained glauconitic sand, overlain by 5 feet of dark-gray, very fine, sandy clay and clay weathering to iron-stained chocolate color. At the top of the bank was 20 feet of alluvium. This was an exposure of the contact of the middle marl member of the Byram formation with the overlying Bucatunna clay member, but in 1939 the exposure had been entirely covered over by alluvium. Just below this old locality is the beginning of an exposure continuous for nearly half a mile of horizontal beds of the middle marl member of the Byram formation. Marl beds of the middle member of the Byram are also exposed in the sharp bend to the south that marks the southeastern end of Wansley Bend in the NW¼NW¼NW¼ sec. 31, T. 4 N., R. 1 E., Rankin County, and these beds dip gently downstream in a continuous exposure for more than half a mile. About 5 feet above water level at the north end of the exposure is a thin bed of bentonite, waxy clay that contains shards of volcanic ash. At the gentle bend to the south-southeast in the NE¼ sec. 1, T. 3 N., R. 1 W., Hinds County, blue-gray clay with laminae of fine sand is overlain by fine blue sand. This material is probably the upper part of the Bucatunna clay member.

Other exposures of the middle marl member of the Byram formation are rare in the Jackson area except in deeply incised creeks near the Pearl River. The lower mile of Trahon Creek in the west half of sec. 18, T. 4 N., R. 1 E., and sec. 13, T. 4 N., R. 1 W., Hinds County, exposes nearly the entire section of the Byram excepting the lower part of the Glendon limestone member and the upper part of the Bucatunna clay member. The highly fossiliferous part of the Byram is well exposed in a branch of Trahon Creek just below the U. S. Highway 51 bridge near the center of the SE¼SE¼ sec. 12, T. 4 N., R. 1 W., Hinds County. Weathered exposures of the middle marl member of the Byram are common to the east in Rankin County, but no fresh exposures were seen.

The Bucatunna clay member of the Byram formation consists of dark-gray slightly sandy micaceous clay and fairly pure, dark-gray clay both of which weather to a chocolate-colored blocky clay containing abundant comminuted plant remains. At a few places this clay contains a bed of fossiliferous silt that resembles some facies of the underlying middle marl member of the Byram. The upper part of the member as delimited in this report and as shown on the geologic maps (pl. 1, 3, and 4) consists of thin-bedded sand and clay with sand becoming more abundant upward in the section. Because the contact of these sandy beds and the underlying characteristic Bucatunna clay member has been seen only at one place and because it did not seem feasible to map the sandy beds separately, these upper beds are included in the Bucatunna in this report, although the writer recognizes that there is a widespread unconformity between the Bucatunna and Chickasawhay limestone and that logically these sand beds, if they prove to be Chickasawhay, should be mapped separately from the Bucatunna.

The lower part of the Bucatunna clay member is well exposed in the banks of the Pearl River near Wansley Bend and has already been described. Probably the best exposure of the upper part of the Bucatunna is in the bank of Richland Creek just above the Brandon-Florence road bridge in the NW¼SW¼NW¼ sec. 12, T. 4 N., R. 2 E., Rankin County, and in the road cuts up the hill to the southwest to the top of the bluff above the bridge. This section is described below:

Section in northeastward-facing slope of Richland Creek, sec. 12, T. 4 N., R. 2 E.

	Feet
Catahoula sandstone: Sand, bedded, light-gray, fine; weathers to gray and yellow, mottled, and pure white sand to top of hill	5.0±
Disconformity(?).	
Byram formation:	
Bucatunna(?) clay member (may be equivalent to Chickasawhay limestone of eastern Mississippi):	
Clay, carbonaceous	.2
Sand, thin-bedded, and gray clay	8.0
Sand, laminated and bedded, yellow and gray; and tan clay	9.0
Clay, bedded, light brownish-gray, breaking with conchoidal fracture; contains comminuted plant remains	15.5
Sand, bedded, brown; and tan clay; limonite at base	3.0
Disconformity(?).	
Bucatunna clay member: Sand, blue-gray, fossiliferous, glauconitic, silty, clayey, very fine	7.0
	47.7

An auger hole bored at creek level at the foot of the exposure of fossiliferous sand penetrated a foot of blue-gray glauconitic sand underlain by 18 feet of thin-bedded very fine black micaceous silty sand and sandy clay containing comminuted plant remains, underlain by 3 feet of similar material containing fossil fragments. This bottom 3 feet (from depths of 19 to 22 feet) is probably the upper part of the middle marl member of the Byram formation, for another hole bored by Mr. MacNeil in 1939 disclosed middle marl member at a depth of 25 feet.

The middle part of the Bucatunna clay member is exposed in a railroad cut 1½ miles north-northeast of Brandon in the SE¼SW¼NE¼ sec. 10, T. 5 N., R. 3 E., Rankin County. An auger hole penetrated 6 feet of surficial red and brown sandy mud underlain successively by 3½ feet of gray and brown clay, ½ foot of greenish-brown silt and gypsum, and ½ foot of bluish-gray fossiliferous silt. The altitude of the top of the hole is 440 feet. Thus the top of the middle marl member of the Byram 10 feet below is 430 feet above sea level. The following section is exposed in a railroad cut 450 feet east of a road crossing and in the cuts of the road to the top of the hill to the north:

Section in railroad and road cuts $1\frac{1}{2}$ miles north-northeast of Brandon

[Altitude at base of section, 443 feet]

	Feet
Brown loam (weathered loess)	7
Byram formation:	
Bucatunna(?) clay member (includes possible western equivalent of Chickasawhay limestone in upper part): Sand, red and gray, thin-bedded; and clay containing thin plates of limonitic sandstone	27
Bucatunna clay member: Clay, gray and brown, breaks with conchoidal fracture, contains comminuted plant remains	5
	39

The contact of the sandy upper part of the Bucatunna clay member with the overlying Catahoula sandstone is exposed in a road cut on the old Jackson highway between Brandon and the railroad bridge about $\frac{1}{8}$ mile north of the center of sec. 16, T. 5 N., R. 3 E. The following section is exposed in this road cut and the large gravel and sand pit at the top of the hill:

Section in cuts of the old Jackson highway at Brandon

	Feet
High-level gravel deposit: Sand, yellow, red, and gray, cross-bedded, medium-grained, containing a little very fine gravel; at base is a bed of limonite	26
Unconformity (undulating surface).	
Catahoula sandstone: Sand, light-gray and yellow, very fine-grained, thin-bedded, slightly micaceous, interbedded with hackly siliceous clay	11
Disconformity(?). (Altitude is 459 feet)	
Byram formation, Bucatunna(?) clay member (may be equivalent to Chickasawhay limestone of eastern Mississippi): Sand (0.1 foot), carbonaceous, passing downward into massive poorly assorted fine-grained gray compact sand locally stained yellow; resembles highly leached sand soils of upland forest regions, thickness varies from 33 inches in the eastern part to 8 inches in the central part to 36 inches in the western part. The top of the bed is nearly a plane surface, but the bottom forms a slight arch as if the old soil was formed on a low hill	3
Clay, gray; alternating with beds of massive gray and yellow sand	9
Sand, massive, yellow; underlain by thin-bedded and laminated brown fine-grained sand containing a few thin beds of clay in upper 3 feet. Passing downward in the section the clay beds are thicker and contain abundant comminuted plant remains. The bottom 3 feet of the exposure consists of brown hackly blocky clay containing abundant comminuted plant remains in beds about 1 to 2 inches thick separated by very thin $\frac{1}{16}$ to $\frac{1}{2}$ inch beds of gray or yellow sand	8
	57

Down the hill to the west, 16 feet of gray clay containing a little gray sand is exposed in a cut whose top is 22 feet below the base of the section described above. In the railroad cut below the highway bridge

268680—54——7

a hard layer of limestone is exposed that is probably the top of the Glendon limestone member of the Byram formation. The altitude of the top of this bed is 384 feet. Thus the difference in altitude between the top of the Bucatunna clay member and the top of the Glendon limestone member in this hill is about 75 feet. As the dip of the rocks here is due south about 30 feet per mile an additional thickness of about 10 feet must be allowed in calculating thickness of the combined middle marl member and Bucatunna clay member of the Byram, or a total of about 85 feet. This compares reasonably well with figures obtained by other methods.

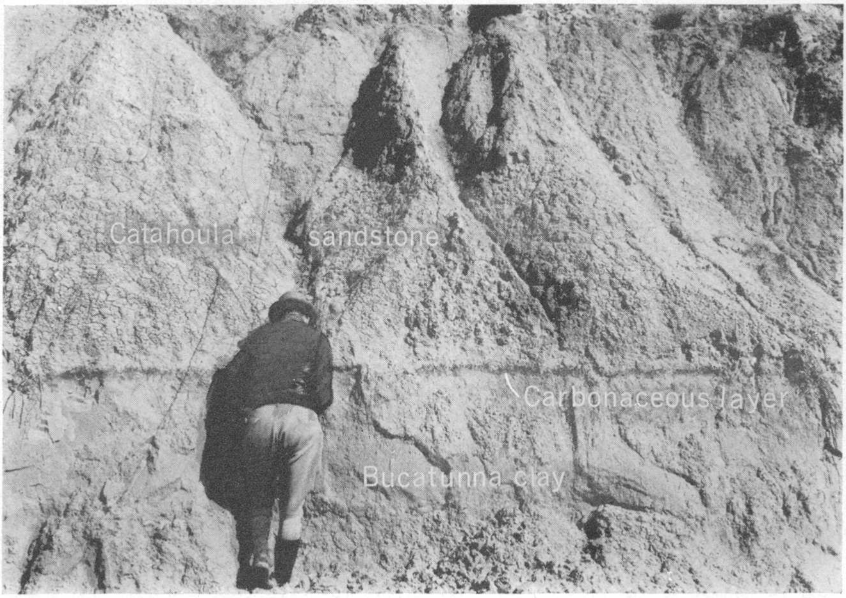

FIGURE 10.—Carbonaceous layer believed to mark the top of the Bucatunna clay member of the Byram formation overlain by basal beds of the Catahoula sandstone. Cut in old Jackson road at the west edge of Brandon, sec. 16, T. 5 N., R. 3 E., Rankin County.

The carbonaceous sand bed (fig. 10) described in the section above and in the section at Richland Creek has been seen at many places in the Jackson area and appears to be traceable over a large area. The writer interprets this carbonaceous bed as an old soil zone formed in late Oligocene time before deposition of the Catahoula sandstone. If this assumption is correct the contact of the Vicksburg group and the Catahoula sandstone should be drawn at the top of the carbonaceous bed and is a disconformity. No other possible contact of the Vicksburg and Catahoula was found in the Jackson area.

Thickness.—The aggregate thickness of the Byram formation including the Glendon limestone member, the middle marl member, the

Bucatunna clay member, and the sandy beds at the top doubtfully referred to the Bucatunna clay member is about 120 feet. The Glendon member was accurately measured in the railroad cut south of Plain (E½SE¼NE¼ sec. 12, T. 4 N., R. 1 E., Rankin County) and an auger hole was bored to the top of the Forest Hill sand. The altitude of the top of the Glendon member at the auger hole, assuming a regular dip, would be 355.8 feet; the altitude of the top of the Forest Hill sand in the auger hole is 321.8 feet. If allowance is made for 10 feet of Mint Spring marl member of the Marianna limestone the thickness of the Glendon member is thus about 24 feet. The minimum thickness of the Glendon member as it is exposed at Hemphill Bluff on Pearl River in the NE¼NE¼ sec. 20, T. 4 N., R. 1 E., Rankin County, is 28 feet. The thickness of the member is, therefore, between 24 and 30 feet.

The composite section of the middle marl member of the Byram formation on Pearl River shows a total thickness of 28.6 feet for this part of the Byram. The exposures at Wansley Bend suggest that this estimate may be slightly too small, but a figure of 30 feet is probably accurate within 5 feet for the Jackson area.

The lower, characteristic part of the Bucatunna clay member is about 25 feet thick as shown by the auger hole on Richland Creek, sec. 12, T. 4 N., R. 2 E., Rankin County. It is possible that the auger hole bored by the writer stopped in fossiliferous Bucatunna clay member, slightly above the middle marl member of the Byram formation. Middle marl member of the Byram was reached in MacNeil's auger hole at 25 feet, or approximately 30 feet below the disconformity (?) between the Bucatunna clay member and the thin-bedded sand and clay above. The upper sandy part of the Bucatunna clay member is 35 feet thick at the Richland Creek locality. The complete section of Bucatunna at Richland Creek is, then, between 60 and 65 feet thick.

Fossil content.—MacNeil, who is studying the fauna of the Mint Spring marl member of the Marianna limestone is also making a critical faunal study of the Byram formation. Useful guide fossils are *Lepidocyclina supera*, *Pecten byramensis*, and *Scapharca lesueuri*. The last species, however, is restricted to the middle marl member and the Bucatunna clay member.

In the Jackson area the best collecting localities of the Byram formation for the more fossiliferous middle and upper parts are at Byram and at the northeast and southeast ends of Wansley Bend.

Stratigraphic relations.—The Byram formation rests with little sign of a physical break on the concretionary sandstone that is believed by MacNeil to represent the Marianna limestone. The Marianna in Wayne County is said to have a thickness of 30 to 35 feet (Blanpied, Oldham, and Alexander, 1934, p. 11), but in the Jackson area the equivalent Mint Spring marl member of the Marianna and the overlying concretionary sandstone assigned to the Marianna by MacNeil are together only about 10 feet thick. This sandstone contains much phosphatic material and may represent a period of very slow or possibly suspended deposition. If so, there may be a diastem between these beds and the Glendon limestone member of the Byram. There is, certainly, a marked change in fauna in passing from the Mint Spring to the Glendon. *Pecten poulsoni* is common in the Mint Spring and the overlying sandstone but is replaced by *Pecten byramensis* in the Glendon; *Lepidocyclina supera* abruptly appears in the base of the Glendon, but has not been found below, although the Marianna species *Lepidocyclina mantelli* has been doubtfully recognized.

The Glendon limestone member is much thicker than the true Glendon of eastern Mississippi and western Alabama and probably should have some other name inasmuch as the typical "horsebone" limestone of Glendon, Ala., is not present in the Jackson area. However, the hard marlstone and limestone here referred to the Glendon occupies the same stratigraphic position as the Glendon limestone member in western Alabama and to avoid duplication of names it has been decided to retain the name for western Mississippi. No break in deposition is recorded between the Glendon member and the middle marl member of the Byram or between the middle marl member and the overlying Bucatunna clay member. In fact at a few places thin sandy and clayey lenses that greatly resemble Bucatunna have been found in the middle member of the Byram. Thus deposition of the Bucatunna appears to have succeeded deposition of the middle marl member of the Byram formation with no break in sedimentation in the Jackson area.

At the one place within the area where the contact of the lower, characteristic Bucatunna clay member with the overlying thin-bedded sand and clay is exposed, the bank of Richland Creek, sec. 12, T. 4 N., R. 2 E., Rankin County, there is a suggestion of a disconformity between the two units. It is largely because of this possible disconformity that MacNeil is inclined to correlate the upper sandy beds with the Chickasawhay limestone. Until more careful study is made of the relations of these sandy beds to the Chickasawhay somewhere in central Mississippi the writer prefers to include them in the Bucatunna.

These sandy beds are overlain by a thin carbonaceous bed that the writer interprets as an ancient soil. If this interpretation is correct the sand is overlain disconformably by the Catahoula sandstone.

Origin.—Most of the Glendon limestone member of the Byram formation was deposited in moderately deep water into which little mud was being transported. The variation in hardness of the different beds, at least in part, is the result of varying amounts of mud. Several samples of the alternating marl and marlstone beds were dissolved in hydrochloric acid. The insoluble residue was greater in the softer beds than in the harder limestones. Clay was not retained in the process, so the exact amount of insoluble material could not be determined, but the sand content varied from ½ to 7 percent. Glauconite was by far the most abundant constituent in most samples with quartz a close second. Limonite is common in most samples and pyrite is locally abundant. The minerals lighter than bromoform constitute on an average 99 percent of each sample; the heavy minerals include zircon, tourmaline, kyanite, sillimanite, garnet, apatite, rutile, epidote, hornblende, staurolite, muscovite, biotite, augite, leucoxene, chlorite, and questionably corundum.

The middle marl member of the Byram formation is much more sandy than the Glendon limestone member indicating conditions nearer shore at this time than earlier. According to Cushman (1922, p. 88) the Foraminifera indicate "that the water at Byram must have had at least subtropical temperature (between 20° and 24° C.)," and that the "marl was deposited in comparatively shallow water (10 to 25 fathoms)."

The Bucatunna clay member records a shoaling of the sea probably caused by the increase in amount of alluvium carried into the sea over the previously deposited deeper-water limestones and marls. The sand beds at the top of the Bucatunna were doubtless deposited under deltaic conditions.

At the top of the Byram formation the carbonaceous layer that rests on highly leached sand at some places and on leached clay at others resembles an ancient soil that was buried by deposition of the overlying Catahoula sandstone.

Physiographic expression.—Much of the outcrop of the Byram formation is masked by surficial deposits, but where these are absent the formation gives rise to low, gently rolling hills only slightly more rugged than the Jackson Prairie belt underlain by the Yazoo clay. The limestone beds of the Glendon limestone member are scarcely thick enough to give rise to caverns, and sink holes are rare in the formation in this part of Mississippi, but gentle depressions caused by solution of the underlying limestone and marl have been seen at 2 places in or near the area. One of these is just south of the bend in the Shiloh road 1½ miles east-southeast of Brandon in the NW¼ SW¼NE¼ sec. 23, T. 5 N., R. 3 E., Rankin County. The natural depression has been put to use by building a dam across the lowest part of the small ridge present on the down-slope side of the sink hole and thus impounding water in a lake to supply cattle with drinking water. The other sink noticed in the region is at a lake near the center of sec. 30, T. 5 N., R. 5 E., half a mile northeast of Shiloh Church, Rankin County. Here the surface has sunk from 10 to 20 feet, forming a lake about 400 feet long and 150 feet wide. A problematic surficial deposit on U. S. Highway 49 about 1½ miles north of Florence in the SW¼NW¼SE¼ sec. 19, T. 4 N., R. 2 E., contains steeply dipping beds of limonitic sandstone and highly contorted sandy limonite. Dr. L. W. Stephenson suggested to the writer that this deposit might be a "fossil" sink hole, caused by solution of the underlying Glendon limestone member. To date no other reasonable explanation has been offered to account for this deposit.

The thin-bedded sand at the top of the Bucatunna clay member gives rise to slightly more rugged topography than the more easily eroded beds below and affords a transition to the hills underlain by the Catahoula sandstone.

MIOCENE SERIES

CATAHOULA SANDSTONE

Name.—The name Catahoula sandstone was introduced by Veatch (1905, pp. 84, 85, 90; 1906, pp. 42, 43) to take the place of the cumbersome name "typical Grand Gulf beds" or "Grand Gulf proper," which was originally given by Hilgard (1860, pp. 147, 148). The type locality is in Catahoula Parish, La.

Areal distribution.—Only the northern part of the area of outcrop of the Catahoula sandstone is shown on the geologic map accompanying this report (pls. 1, 3, and 4). The formation crops out in a belt between 15 and 20 miles wide extending eastward into Alabama from the bluffs overlooking the Mississippi River. The formation is known from Texas to Alabama and appears to be represented in Florida, at least in part, by the Tampa limestone.

Lithologic character.—The Catahoula sandstone consists predominantly of earthy sandstone and blue-green to gray, silty, sandy clay. Thick discontinuous sandstone beds are common in the formation and locally these sandstone beds have been cemented into dense quartzite by opaline silica. Gypsum and salt are common accessory constituents of the rocks, and deposits of volcanic ash, tuff, and bentonite have been reported from the formation. In the part of Mississippi that the writer has studied, however, he has not seen any material that is definitely pyroclastic.

The lower part of the Catahoula sandstone exposed at Brandon is described with the underlying Bucatunna(?) clay member of the Byram formation on page 93. The contact of the Catahoula with the underlying Vicksburg group was not exposed on the Pearl River in the summer of 1939. The first Catahoula in place seen on a trip down the river on August 7, 1939, was on the left bank at a bend to the southwest in the NW¼NE¼NW¼ sec. 7, T. 3 N., R. 1 E., Rankin County, where 4 feet of dark greenish-blue waxy silt is exposed. On the same bank ¼ mile downstream 4 feet of blue silty sand is exposed. At the next bend to the southeast on the right bank in the SE¼NE¼ sec. 12, T. 3 N., R. 1 W., Hinds County, 11 feet of greenish-gray thin-bedded silt weathering to black, red, and brown, is overlain by a 1.7-foot layer of indurated poorly assorted but predominantly fine-grained sand. The bed of silt exposed here has been observed near the base of the Catahoula at many places in the Jackson area and appears to be a bed that can be traced over a considerable distance. The silt is well exposed at the next bend to the south and west in sec. 7 and the slightly indurated layer is at about water level along the west reach of the river as far as the center of the NE¼SE¼ sec. 12. At the bend to the south-southeast in the E½NW¼SE¼ sec. 12, 9 feet of dark-blue nonplastic slightly silty clay is both overlain and underlain by bedded hard sandstone. A pile of boulders of Catahoula sandstone borders the river here and also at several of the other bends downstream. The first prominent exposures of massive sandstone along the river are in its east by south reach in the NE¼NE¼ NE¼ sec. 24, T. 3 N., R. 1 W., and in the continuation of this reach in sec. 19, T. 3 N., R. 1 E.

The carbonaceous bed that is believed to mark the top of the Vicksburg group is exposed in a shallow road cut near the center of sec. 8, T. 4 N., R. 2 E., Rankin County, and here it is associated with a 3-inch bed of kaolin. On the same road ¼ mile east by south the prominent layer of black and red clayey silt described in the preceding paragraph is exposed about 10 feet above the carbonaceous bed. Here about 20 feet of the silt is exposed, and it was seen in several road cuts farther east on the same road. On the Brandon-Florence road in the east half of sec. 11 the hill to the northeast of D. W. Webb's house shows 13 feet of compact dark-gray and red silt overlain by 6 feet of hard gray and yellow hackly sandstone, which in turn is overlain by 33 feet of surficial coarse sand to the top of the hill at Mr. Webb's house.

Quartzite has not been seen by the writer in the area shown by the geologic map, but is exposed at several places nearby. The following section is exposed at a quarry (fig. 11) 2½ miles east of Raymond in the NW¼SW¼NW¼ sec. 23, T. 5 N., R. 2 W., Hinds County. The stone from this quarry is said to have been used between 1833 and 1839 in building the old Mississippi State Capitol on State Street at Capitol Street in Jackson.

FIGURE 11.—Catahoula sandstone used as rip-rap and building stone, quarry in sec. 22, T. 5 N., R. 2 W., Hinds County.

Section in quarry 2½ miles east of Raymond

	Feet
Brown loam (weathered loess) and colluvium	4.0
Catahoula sandstone:	
Sand, light-gray, very fine-grained, clayey	1.0
Sandstone, soft	1.0
Clay, light-gray sandy	.5
Sandstone, medium-hard	.8
Sand, soft, clayey	.5
Sandstone, medium-compact, cross-bedded	2.0
Sandstone, soft, cross-bedded	.5
Sandstone, medium-hard, cross-bedded	1.5
Sand, soft, clayey	.1
Sandstone, very hard, cross-bedded, tightly cemented; the lower part, concealed in most parts of the quarry consists of cross-bedded pink sandstone	4.5
	16.4

At the Gant quarry 4 miles southwest of Terry (T. 3 N., R. 1 W.), there are 3 layers of hard sandstone of which the bottom layer, 2 to 3 feet thick, is quartzite; the other layers are about 1½ feet thick and consist of softer sandstone. The rock from this quarry was used for building stone, riprap for levees, floors of spillways, and as railroad ballast.

An 8-inch layer of cross-bedded quartzite is exposed in a shallow road cut on an eastward-facing slope in the SE¼NE¼SE¼ sec. 13, T. 3 N.., R. 1 E., Rankin County, about 4 miles due south of Florence. The quartzite is very brittle and breaks into fragments with sharp cutting edges. J. J. Glass (oral communication) of the Geological Survey has identified the cement as opal. This is the only deposit of quartzite that the writer has seen east of Pearl River.

The extraordinary amount of salt in some parts of the Catahoula sandstone was observed by Hilgard (1860, pp. 151, 152) who says:

> The materials of the formation in S. Rankin are prevalently sandy, generally white "rotten" sandstones, but yet frequently interstratified with lignitic, and generally very fetid and saline, clays. Outcrops of this kind are very common on the waters of Steen's Creek, where the saltiness of the clays gives rise to numerous cattle-licks; in some instances, the cattle have eaten caves into the hillsides; and I have found a crust of white salt, ¼ inch thick, formed by evaporation on a ledge of clay in the bed of Steen's Creek.

One of these caves, locally known as the "Rock House," is excavated into the side of a steep-walled ravine on the north side of a ridge in the SW¼NE¼ sec. 25, T. 3 N., R. 2 E., 1½ miles south of Star, Rankin County. The cave is about 15 feet deep (horizontally), 21 feet wide, and the roof is about 6 feet high. On the walls are depressions that have been licked out of the rock by the tongues of animals. The bed containing the salt is soft, light-gray to yellow, very fine to fine-grained, cross-bedded sand and is about 7 feet thick; it is overlain by a 4-foot bed of tightly cemented cross-bedded, fine to medium-grained, white sandstone containing small balls of white clay. Analyses of the rock containing the salt by Francis L. Schmehl formerly with the Geological Survey show that it contains from 0.52 to 2.12 percent NaCl. "Potassium is present, by flame test. Mr. R. K. Bailey estimates that 2 to 5 percent of the soluble salts are potassium salts. Thus KCl would be about 0.08 to 0.10 percent."

The hard sandstone overlying the salt bed was observed at many places to the south of the salt lick and it doubtless will prove to be a traceable bed locally. The salty bed is also exposed down the hill immediately north of the public road in the SW¼SE¼NW¼ sec. 25, half a mile west of the salt-lick cave.

Thickness.—Only the lower part of the Catahoula sandstone is exposed within the area shown on the geologic maps (pls. 1, 3, and 4), and the writer has no factual knowledge of the thickness of the formation.

Fossil content.—Few animal fossils have been recovered from the Catahoula sandstone except in a railroad cut a mile west-southwest of Mendenhall near the center of the SE¼NE¼ sec. 4, T. 1 N., R. 4 E., where obscure prints in sandy clay were discovered by Henry N. Toler in 1931.

Berry (1916b, p. 231) has described a meager flora from the Catahoula sandstone, including a specimen of a climbing fern (*Lygodium mississippiensis* Berry) from a locality near King, 5 miles south of Florence, Rankin County.

Stratigraphic relations.—The writer interprets the carbonaceous layer immediately underlying the Catahoula sandstone as an old soil zone on the Bucatunna clay member of the Byram formation; if this conclusion is correct the Catahoula must rest on these older rocks disconformably. The upper contact with the overlying Hattiesburg clay is reported by many geologists working in the area to be conformable.

The basal part of the Catahoula sandstone is believed to be approximately equivalent to the Tampa limestone of the Miocene series, but until identifiable fossils are found this correlation must be based merely upon similar stratigraphic position.

Origin.—Matson (1916b, pp. 220, 221) discusses the origin of the Catahoula sandstone as follows:

> All geologists who have studied the Catahoula sandstone have agreed that it is nonmarine, their conclusions being based largely on the absence of remains of marine organisms and the presence of fossils of nonmarine origin, such as leaves and a few scattered fresh-water shells of unios and anodonts, together with the character of the materials constituting the formation. The presence of a large amount of lignitized wood and numerous thin layers of lignite gives evidence of deposition in swamps, and the character of the materials themselves indicates deposition near the strand line, where there are many variations in the kinds and arrangement of sediment. The formation is on the whole sandy because of the influx of swift currents bearing coarse detritus, though the presence of layers and lenses of more or less sandy clay shows that the currents were at times gentle, and, on the other hand, the occurrence of pebbles of moderate size in the sands indicate that at times the streams had a high velocity.
> * * * It has generally been assumed that the conditions of Catahoula time were estuarine. * * * The theory of estuarine origin for a portion of the formation is apparently confirmed by the character of the deposits and by the fact that they contain more or less gypsum, which was doubtless deposited by evaporating saline waters. * * *
> The presence of a large amount of unweathered feldspar suggests that the sands had not been subjected to long-continued weathering in a moist climate.

To account for the salt in the formation the writer suggests the hypothesis that at least the salty beds were deposited in lagoons behind a bar that at low tide was above sea level, cutting off all egress for the water that flowed over the bar during high tide. In a hot, dry climate there would be a gradual increase in the salt content of the water trapped in the lagoon that in time would cause deposition of the salt in sand that was being brought into the lagoon by wind or streams.

Goldman (1915, pp. 261–287) has studied samples of the Catahoula sandstone from Texas and concludes that the "closest affinities of the Catahoula sandstone are with aeolian and beach sands." Although no petrographic studies have been made of the sandstone in Mississippi, deposition of the sand in the salty beds might well have been by the wind.

The hypothesis of an arid climate is not confirmed by the few leaves found in the formation, for according to Berry (1916b, pp. 228, 229) some of the plants whose leaves he has studied live in coastal swamps. He says, however, "the flora contains no upland or inland types and may be regarded as a strictly coastal flora made up of groups comparable with those found along the strand in the present-day Tropics."

Physiographic expression.—In general the area of outcrop of the Catahoula sandstone consists of fairly rugged hills separated by narrow flat valleys. At most places in the Jackson area, however, the Catahoula is overlain on the hilltops by surficial deposits, and these contribute to the strong relief of the Catahoula portion of the area. Cuestas caused by beds of hard sandstone are common in the area of outcrop of the formation, but none of these are present within the mapped area. A good example of one of these cuestas is afforded by the outcrop of the hard layer overlying the salt-bearing sandstone south of Star. Many or perhaps most of these cuestas are local in extent because the sandstone layers are not continuous. The softer parts of the formation are subject to gullying and this increases the relative relief.

A small area of about 15 square miles that constitutes most of the drainage basin of Dry Creek in T. 4 N., Rs. 2 and 3 E., Rankin County, is much flatter than most parts of the belt of outcrop of the Catahoula sandstone. The author has found no convincing reason for this flat topography but the area may have been reduced nearly to base level by the drainage of Dry Creek; or perhaps the more rugged topography of surrounding regions is due more to the remaining capping of surficial sand and gravel than to the underlying Catahoula sandstone, for the sandstone of the lower part of the Catahoula is much softer than that in the middle part and at most other places this lower softer part of the formation is covered by a resistant capping of surficial deposit.

SURFICIAL DEPOSITS

Nearly all the Jackson area is covered by surficial deposits of one kind or another. On the geologic map these have been differentiated into high-level gravel deposits, stream-terrace deposits, loess or brown loam, alluvium, and undifferentiated surficial deposits. The writer has assigned these surficial deposits to the Quaternary for reasons given hereafter, but most earlier reports have included much of the surficial material in the Citronelle formation of Pliocene or Pleistocene age. The boundaries of many of these deposits are indefinite and the boundary lines shown on the map should be considered only approximations.

Most of the work in the Jackson area consisted of determining the relations and contacts of the formations up to and including the Catahoula sandstone. At the time the field work was being done the surficial deposits seemed of importance mainly because they concealed older beds, consequently future workers may modify to some extent the classification of these deposits and their boundaries. With the information now available, however, the treatment and mapping of the deposits is probably sufficiently valid. A systematic study of surficial deposits over a wide area in the Coastal Plain is urgently needed, and until such a study is made, any classification will be adequate only for local areas.

The oldest surficial formation in west-central Mississippi is the Citronelle formation which consists largely of more or less cross-bedded red and yellow sand and fine to coarse gravel, which contains pebbles averaging about an inch in diameter. Quartz is the most common constituent, and the quartz pebbles are well rounded. Chert, sandstone, and quartzite pebbles and fragments of silicified wood are also common.

The Citronelle formation does not crop out within the area of the geologic map, but it caps high hills in the southern part of the Florence quadrangle, just south of the mapped area, and forms the cap of a high ridge south of Morton in Scott County, east of the mapped area. These deposits are outliers of a thick mantle of gravel that covers much of southern Mississippi and forms an extensive plain near Brookhaven. In the Jackson area the Citronelle appears to have formed the source of much of the gravel in the high-level gravel deposit and in the river terrace deposits.

HIGH-LEVEL GRAVEL DEPOSIT

Areal distribution.—The high-level gravel deposit was once probably a continuous deposit throughout much of the Jackson area, but it has been so extensively eroded that now only remnants remain. The most extensive areas now covered by the deposit are in the northern part of the Florence quadrangle in T. 4 N., Rs. 1 and 2 E.; on the hills near Brandon; on Ware Hill near Pelahatchie; and capping two of the higher hills between Fannin and Goshen Springs. Small hills west of Pearl River just north of Forest Hill School in sec. 10 and 15, T. 5 N., R. 1 W., are also capped by gravel assigned to this unit.

Lithologic character.—In general the gravel in this deposit is finer than that in the Citronelle formation. One of the best exposures of the unit is in a sand and gravel pit at the crest of the hill on the old U. S. Highway 80 at Brandon near the center of sec. 16, T. 5 N., R. 3 E., Rankin County, where the deposit rests on the basal sands of the Catahoula sandstone. The Brandon section is described on page 93.

On the western crest of Ware Hill, southwest corner, NW¼NW¼, sec. 19, T. 6 N., R. 5 E., 40 feet of compact crossbedded red, gray, and yellow ferruginous coarse sand and fine gravel rests disconformably on finer material probably of the Forest Hill sand.

Gravel is somewhat more common in the high-level gravel deposit in those outcrops nearer Pearl River. The higher hills near Cleary, which is in sec. 27, T. 4 N., R. 1 E., Rankin County, are capped by one of these deposits of sand and gravel. A gravel pit a mile south of Cleary in the NE¼NE¼NW¼ sec. 34, T. 4 N., R. 1 E., shows 15 feet of crossbedded coarse red sand and fine gravel. The gravel is predominantly of quartzitic material, but contains some quartz and chert. Most of the pebbles average ¼ inch in diameter but the largest pebble found was of sandstone 1 by 1 by 3 inches. The deposit here is typical of those near Cleary. Farther east in the Florence quadrangle the secondary gravel is somewhat finer, probably because more of the material from the underlying formations is mixed with it.

The deposits west of Pearl River are coarser than those near Cleary and the pebble size approaches that of the Citronelle formation, the average pebble size being a little less than 1 inch; the largest pebble seen was 6 inches long.

Thickness.—At most outcrops only the lower part of the high-level gravel deposit is preserved, the upper part having been eroded away. Near Cleary and Monterey (sec. 16, T. 4 N., R. 2 E.), however, the present surface is probably very nearly the original surface, and there the thickness of the unit is about 60 feet. At Ware Hill 40 feet was measured, at Brandon, 26 feet; and on the hills north of Forest Hill School, only 20 feet.

Stratigraphic relations.—The high-level gravel deposit rests unconformably on the older formations of the area from the Forest Hill sand to the Catahoula sandstone. The formation is overlain by the brown loam, a weathered loess of Pleistocene age.

The unit is believed to be younger than the Citronelle formation because it lies at a lower altitude and appears to contain material derived from the Citronelle.

Origin.—The high-level gravel deposit was deposited in the flood plains of one or more rivers that swept back and forth across the area west of Ware Hill. It consists of deposits derived from the Citronelle formation on the higher hills to the east and of material derived from the Tertiary deposits of the Coastal Plain which crop out to the north. The particular river which deposited the sand and gravel is not known but may have been an ancestor of the Pearl, possibly including drainage now belonging to the Big Black. High hills between the Jackson area and the Mississippi River probably rule out the Mississippi River as the depositing agent.

Physiographic expression.—The bluffs of the flood plain on which the high-level gravel was deposited do not now exist within the Jackson area, but the gravel should be considered a high-level river terrace deposit. At present it caps hills of medium height within the area.

The plain originally at the surface of the unit can be reconstructed roughly from the remnants that have not been eroded away. This plain now has an altitude of about 420 feet near Cleary, 430 near Monterey, 480 feet north of Forest Hill School, 520 feet at Brandon, 520 feet at Ware Hill, and probably greater than 500 feet between Fannin and Goshen Springs.

Shaw (1918, pp. 154–156) suggests that the terrace deposits of the Citronelle formation are warped and that the higher ones slope away from Jackson. The data on the high-level gravel deposit so far as they go seem to bear this out.

STREAM TERRACE DEPOSITS

Most of the larger stream valleys within the Jackson area are bordered by high-level terrace deposits. In addition to these some of the larger streams have lower terraces only a few feet above the alluvial plain; these lower terraces for convenience have been mapped with the alluvium.

The streams with well-developed terrace deposits are the Pearl River, Steen Creek, Richland Creek, Pelahatchie Creek, the Strong River, and Robinson Creek.

The terrace deposits consist of crossbedded red and gray sand and fine to coarse gravel. The coarsest gravel seen is in the deposits bordering the Pearl River, where it is mined north of Byram, in Jackson, and from the hills just west of Pearl River northeast of Jackson. The terraces along Steen Creek, particularly southwest of Florence contain somewhat coarser gravel than is common in the terraces of the creeks, but this indicates that the immediate source is probably the Citronelle formation and the high-level gravel deposit, both of which are present on hills near this stream.

The deposits vary greatly in thickness, but none were seen that exceed about 40 feet in thickness. In general the average thickness appears to be about 20 feet.

The base of the terrace deposits was seen at only a few places, but where seen the deposits rest on the older formations of the Eocene, Oligocene, and Miocene. The deposits are overlain by the brown loam, and thus may be considered early Pleistocene. At no place was terrace gravel found resting on brown loam, but if the gravel deposits represent ancient flood plains, any brown loam that might have been present would have been washed away by the streams before deposition of the sand and gravel.

The terraces rise upstream. On the Pearl River the top of one of the terraces rises from about 290 feet near Byram to about 320 feet near the mouth of Pelahatchie Creek. On the west side of Pearl River a somewhat higher river terrace has an altitude of about 360 feet north of Byram and rises to about 400 feet at the north edge of the Jackson quadrangle.

An interesting feature of the lower terrace on the Pearl River is its width of nearly 2 miles east of Byram. The material at the surface at the T-road at French's Store in the NW¼ sec. 28, T. 4 N., R. 1 E., consists of 4 feet of light-gray, yellow-stained very tough poorly assorted sandy clay overlain by 5 to 10 feet of brown loam. The tough clay somewhat resembles material in the Catahoula sandstone and the outcrop has been generally assigned to the Catahoula. The writer is now of the opinion, however, that this material is alluvium of the Pearl River on this low river terrace, and that the Pearl River once flowed through this low sag between the low ridge to the west and the high hills to the east.

LOESS AND BROWN LOAM

Very little loess of the kind that forms a thick mantle on the bluffs overlooking the Mississippi River is present in the Jackson area, and the little that is present forms a thin coat on the underlying brown loam in the western part of the area. The eastern equivalent of the loess is an extensive mantle of light-gray to tan compact loam which has been called in many earlier reports "the brown loam."

The brown loam (weathered loess) in the Jackson area consists of compact light-gray to tan silt containing a few scattered sand grains. No stratification lines have been seen in the loam, although a pseudostratification attributable to weathering is noticeable in some exposures. Like the true loess the brown loam is a finely ground rock flour in which quartz is the dominant mineral, but in which are present other minerals resistant to weathering, such as zircon and garnet.

The blanket is nearly complete in the western part of the Jackson area where it is from 10 to 20 feet thick, but in the central and eastern parts it is much thinner and is present only as small patches. The boundaries of the deposit as shown on the geologic maps (pls. 1–4) have been copied with important modifications from the soil maps of Hinds, Madison, and Rankin Counties, where the brown loam is mapped as Grenada silt loam and in a few places as Pheba silt loam. The small deposits of true loess in the western part of the area are mapped by the soil surveyors as Memphis silt loam.

Snail shells are common in the deposit of true loess in Warren County and elsewhere, but no fossil shells of any kind have been seen in the brown loam within the Jackson area.

The brown loam is believed by most geologists to be a blanket deposit of silt blown by the wind over western Mississippi during the Pleistocene. When the ice of the continental glaciers melted in the northern part of the Mississippi drainage basin, the water that ran off carried in suspension great quantities of finely divided rock flour. This sediment was dropped by the river along its flood plain, there to be picked up by winds and spread great distances in dust storms. Most of the rock flour settled to the ground not far from the source and formed the thick deposits of true loess that constitute the top of the bluff bordering on the east the Mississippi River flood plain, but some of it blew much farther east. The wind that carried it over the soils derived from the Tertiary formations picked up a little sand and mixed it with the much finer rock flour. This mixture settled to the ground to form the brown loam. The eastern extremity of this brown loam is not known definitely and there may be extremely thin deposits in eastern Mississippi, for there is no reason known why the dust could not be carried hundreds of miles.

No water-laid loess is known in the Jackson area except small deposits that have been reworked since deposition of the main blanket and now make up most of the alluvium of some of the smaller streams.

The brown loam covers the older formations in the western part of the Jackson area and consequently subdues the relief slightly. In general the deposit appears to be thicker on the southern slopes of hills than on the northern slopes, but this may be partly due to later erosion. The true loess, farther west, strikingly exhibits its well-known tendency to stand in vertical walls. The brown loam, on the other hand, does not form such perfect walls. Most cuts in the material, either natural or artificial, slope at a steep angle and weather to a crenelate bank.

ALLUVIUM

All streams, both running and dry, within the Jackson area are in valleys which have a floor of alluvium varying in width and thickness. On the geologic maps (pls. 1–4) only the larger areas of alluvium are shown. Included in the same pattern are low stream terrace deposits the surfaces of which are only a few feet above the alluvium. Streams along which these low terraces were seen include the Pearl River, Richland Creek, Pelahatchie Creek, and Bogue Chitto Creek and its tributaries in the northwestern corner of the area.

The alluvium is composed of gravel, sand, silt, and clay, at a few places intimately mixed, but generally differentiated into a stratified deposit by the action of the depositing stream. At many exposures which show the entire thickness of the alluvium the materials are assorted with gravel at the base, followed by sand, which is overlain at the top by sand, silt, and clay. Much organic matter is present in the alluvium, particularly along the Pearl River, where the wide, flat bottom has given rise to swampy conditions. Along many of the streams west of the Pearl River the alluvium is made up almost entirely of brown loam reworked from the hills within the drainage basin.

Characteristic of the alluvium along the Pearl River is the section exposed on the right bank just below the railroad trestle near the center of sec. 15, T. 5 N., R. 1 E., where a 3-inch layer of gravel, containing pebbles of quartz and chert as large as 1½ inches in diameter, is overlain by light brownish-gray silt and fine-grained sand, containing abundant ferruginous concretions and much reworked loess. The alluvium in this outcrop is about 20 feet thick, and rests unconformably on 4 feet of Yazoo clay.

At several outcrops north of Jackson the alluvium consists of buff to cream-colored somewhat carbonaceous sand and silt, containing lignite at a few places.

A few fossil shells of fresh-water mollusks were found in 1931 in the alluvium of Hanging Moss Creek at the mouth of Whiteoak Creek in the SW¼SE¼NE¼ sec. 18, T. 6 N., R. 2 E., Hinds County, in coarse brown sand. H. G. Richards studied these specimens and collected others at the same locality. He lists (1938, pp. 27–46) the following species: *Cincinnatia cincinnatiensis* (Anthony), *Pomatiopsis lapidaria* (Say), *Sphaerium sulcatum* (Lamarck), *Pisidium dubium* (Say), and *Pisidium* cf. *P. variabile* Prime. All these species have been reported living in the southern States, but some are more common farther north.

Alluvium is being deposited today during each flood on Pearl River, but only fairly fine material is spread on the flood plains, although gravel is accumulating in bars at some places in the bed of the river.

Characteristically the deposits of alluvium have a nearly plane surface, as shown by the wide, flat bottoms of most of the streams in the area. On some of the larger creeks and along the Pearl River, however, natural levees about two hundred feet wide and as high as

5 feet have been formed by the rapid settling of suspended sediment at time of floods. As the flood waters rise above the banks of the streams the swift flow of the current in the channel, which keeps the material in suspension, is checked by vegetation, and a part of the load is dropped. In general the natural levees contain coarser material than the swamps and bayous farther away from the channel.

UNDIFFERENTIATED SURFICIAL DEPOSITS

Into the category of undifferentiated surficial deposits of Quaternary age, (see geologic maps, pls. 1–4) are placed the thicker masses of colluvium, or material now being washed down the slopes of the hills, slightly shifted residual material, and those surficial deposits that have not been assigned to one of the classes described above. Several anomalous masses of fine red sand, locally containing clay balls and blocks of laminated sand, are mapped in this category. The material appears principally to be reworked Forest Hill sand. The masses may be remnants of once-extensive alluvial fans formed when the relative relief between the areas underlain by the Forest Hill sand and the Yazoo clay was greater than it is today. The larger masses of this sand are in Ts. 7 N., Rs. 1 E. and 1 W., and on Red Hill in T. 5 N., R. 2 E. A high hill in secs. 9 and 16, T. 6 N., R. 3 E., and the ridge between Fannin and Goshen Springs, in T. 7 N., Rs. 3 and 4 E., Rankin County, are covered by a mass of red sand questionably mapped as Forest Hill sand; it is quite possible that these masses should be included in the undifferentiated surficial deposits.

STRUCTURE

The Jackson area is on the east flank of the syncline that gives rise to the Mississippi embayment, and the western edge of the mapped area is about 25 miles east of the synclinal axis (see fig. 1). The embayment syncline plunges toward the south so that the formations of central and southwestern Mississippi dip generally toward the southwest rather than west toward the axis of the syncline.

In the mapped area the regional dip of the formations exposed at the surface averages about 25 feet per mile S. 25° W., but this regional dip is interrupted by the large dome, commonly called the Jackson anticline, and by minor irregularities described hereafter.

STRUCTURAL FEATURES SHOWN BY EXPOSED FORMATIONS

During the course of investigations within the Jackson area numerous determinations of altitude were made of several key horizon markers, especially the contacts of the various units described under the section on stratigraphy. The thicknesses of the various formations were determined from wells and from projected dips, and all altitudes were reduced to a single datum surface, the top of the Cockfield formation. Structure contour lines were then drawn on this datum surface with the result shown on the map of areal geology, plates 1 to 4.

The main structural feature within the area is the Jackson anticline, an elongate dome whose longest axis trends about S. 35° W. The dome has a maximum width from northwest to southeast of about 23 miles and a length of more than 25 miles. The crest of the dome is in the northeastern part of the city of Jackson in secs. 35 and 36, T. 6 N., R. 1 E., where the Cockfield formation crops out about 600 feet higher than it would if the regional dip had continued through this area. The strata dip fairly regularly away from the crest at a nearly constant rate of about 70 feet to the mile except toward the northeast where the dip is gentler, averaging about 15 feet to the mile. Locally on the south side of the dome the dip is much steeper reaching extremes of 150 and even 200 feet to the mile. The writer does not have well data at the northeast end of the dome to determine the exact closure, but such data as are available indicate that the closure is at least as great as 280 feet and less than 350 feet.

Synclines are well developed southeast and northwest of the Jackson anticline. The one to the northwest is irregular, having two branches, one which trends northeast through the corner of Ts. 7 and 8 N., Rs. 1 E. and 1 W., and another which trends east through the middle of T. 7 N., R. 1 E. The latter branch is the one which contains the outliers of Glendon limestone member of the Byram formation in the northwestern part of the Jackson quadrangle. The syncline to the southeast of the Jackson anticline is a deep structural trough that trends north-northeast through Brandon in T. 5 N., R. 3 E. In this syncline the Catahoula sandstone crops out surrounded to the east, north, and west by deposits of the Vicksburg group.

Eastward from the Brandon syncline the contour lines are somewhat sinuous suggesting that local irregularities of compaction of the underlying sediments have given rise to low anticlines and synclines.

South of the Jackson anticline the only unusual structural feature noted is a reversal in dip south of Byram, which was detected by anomalies in the dip of strata on the Pearl River, and by a few anomalous altitudes of the contacts of the Forest Hill sand and the Mint Spring marl member of the Marianna limestone and of the Bucatunna clay member of the Byram formation and the Catahoula sandstone in the area east of the river. The structure is shown on the geologic map as a plunging anticline, but it is possible that a fault has raised the strata to the south relative to those to the north. At the northeastern end of Wansley Bend the strata of the Byram formation dip toward the west at a rate believed to be about 300 feet to the mile.

No large faults have been seen within the area, but faults of small displacement and anomalous dips, such as those at Wansley Bend, suggest that faults of considerable magnitude may be present. Hopkins (1916, pp. 111–112) describes evidence of two possible faults: one on Richland Creek in sec. 11, T. 4 N., R. 2 E., half a mile down the creek from the Brandon-Florence road, and the other on the Pearl River at the mouth of Richmond Lake in sec. 3, T. 4 N., R. 1 E. The evidence for the fault on Richland Creek is a bed of Catahoula sandstone that dips from 50°–70° N. 10° E. The existence of this fault is problematic; Henry N. Toler and the writer in 1932 bored auger holes on both sides of the supposed fault and found greenish-gray nonglauconitic, noncalcareous sand at approximately the same depth in each hole.

The evidence of faulting on the Pearl River is the repetition of a slightly indurated marl bed in the Yazoo clay, which is described on page 58. This soft limestone dips downstream 6° and is repeated twice within the next 400 feet downstream. The existence of faulting depends on whether there is one limestone bed whose outcrop is repeated or three beds all dipping at the same rate. Evidence in favor of faulting is the rate of dip, which is exceptionally great for this part of the Coastal Plain. Futhermore a mile downstream in the NW¼SW¼ sec. 10, there are several small faults affecting the contact of the Yazoo clay and the Forest Hill sand.

BURIED STRUCTURAL FEATURES

Like many of the larger structural features of the Gulf Coastal Plain the Jackson anticline becomes accentuated with depth. The structure of the base of the Sparta sand, intermediate between the surface and the gas-bearing zone, is more complex than the structure at the surface and the dips on the crest are somewhat steeper. At this depth two pronounced anticlines are present—one having its crest in secs. 1 and 12, T. 5 N., R. 1 E., and the other having its crest in secs. 25, 26, and 35, T. 6 N., R. 1 E. The dip away to the sides of the main Jackson anticline, however, is not much greater than the dip of the strata exposed at the suface; it appears to average about 100 feet to the mile.

Plate 6 is a structure contour map of the top of the Clayton formation the cap rock of the gas field. Although nearly 190 wells have been drilled within the approximately 27 square miles, that contain the gas field, the configuration of the surface of the Clayton (cap rock) is very imperfectly known as it is highly irregular. The map included in this report presents a possible interpretation of the configuration; with the same data other geologists have prepared maps showing a different structural pattern. The irregular shape of the surface of the Clayton cap rock has resulted in many wells being drilled in places that looked most promising for the production of gas, but which proved to be minor structural depressions too low to produce. The structure map included here shows at least 8 pronounced anticlines or domes and at least 4 deep synclines or basins on the crest of the main anticline. From the data available it seems likely that the different domes may be even more separated from each other than shown. Possibly a number of faults have raised some of these domes above the adjacent synclines, but no faults are shown on the map, for the inclusion of faults made the structure more complex without affording greater accuracy. Possible faults include one approximately on the section line between secs. 35 and 36, T. 6 N., R. 1 E., and extending south and southwest between secs. 1 and 2, T. 5 N., R. 1 E., into sec. 11, and perhaps still farther south along the west edge of sec. 14. If this fault is present the raised block is on the east and the fault is most pronounced in the eastern part of sec. 2, dying out toward the north and the south, but becoming prominent again in sec. 11. Another possible fault is in the northern part of sec. 13, T. 5 N., R. 1 E., extending east into sec. 18, T. 5 N., R. 2 E., with the raised block on the north. The validity of this fault is suggested by the fact that to the south where all the oil has been produced in the field the top of the gas rock is somewhat higher structurally than is easily accounted for.

There seems to have been no communication of gas between some of the isolated domes on the anticline, for the encroachment of edge water took place at different rates. The two most notable areas of this kind are a small anticline in secs. 10 and 11, T. 5 N., R. 1 E., and a small dome on the line between secs. 7 and 18, T. 5 N., R. 2 E. The wells in sec. 10 and 11 had a rock pressure (shut-in pressure) consistently higher than other nearby wells in secs. 11 and 12, according to Munroe (1935, p. 887). The small dome in sec. 18, T. 5 N., R. 2 E., Rankin County produced gas long after the region structurally higher to the west, was drowned by salt water.

The top of the Clayton formation slopes steeply away from the gas field in all directions and the dome has a closure to the northeast of more than 1,500 feet.

Very little is known of the structure of the rocks below the gas rock in the Jackson area. Rocks of Eutaw and Tuscaloosa age are known on the sides of the structure, but not on the crest unless the black clay found in sec. 35, T. 6 N., R. 1 E., and in sec. 13, T. 5 N., R. 1 E. may be of Tuscaloosa age. On the crest the gas rock appears to be underlain by the Cotton Valley(?) formation. The Cotton

Valley(?) formation was raised into a steep-sided dome by the intrusion of the igneous rock, and formations of Tuscaloosa and Eutaw age were either not deposited generally over the crest of the dome, or possibly parts of the formations were deposited and then mostly eroded away, except for the thin, lake deposits found in two basins. It is certain that the gas rock was deposited on the truncated edges of older formations of both Cretaceous and Jurassic(?) age. Furthermore, the gas rock at Jackson is believed to be of late Upper Cretaceous age, possibly Prairie Bluff, and the older chalk of the Selma group was probably not deposited. This suggests uplift during early Selma time.

Many of the cores taken from the Cotton Valley(?) formation consist of strata that dip strongly. The wells from which these cores were obtained are believed to be relatively straight, so that the inclination of the bedding in the cores is probably approximately the same as in the rocks. Much of this apparent dip, however, may be crossbedding, and the truly structural dips in the formation may not be as steep as appears from the descriptions. Some of the cores in the Gulf Hamilton and Gulf Hannah wells are cut by vertical or steeply dipping planes with different kinds of rock on the two sides. The writer feels reasonably certain that these planes are fault surfaces. As the chance of coring fault surfaces is small, faulting must be common in these rocks.

ORIGIN OF THE JACKSON ANTICLINE

The Jackson anticline is the result primarily of crustal warping, which accompanied the igneous activity, and secondarily of compaction of shales relative to sandstone and igneous rock. The original dome underlying the Jackson field was formed during the intrusive and volcanic activity. At this time the Cotton Valley(?) formation was domed upward and probably fractured by numerous faults. It seems probable that this structurally high area remained above sea level throughout much of Tuscaloosa and Eutaw time and the top was eroded away. Large basins on the Jackson island were filled with volcanic tuff and later by lake deposits. The minor irregularities of the top of the Clayton formation probably represent the compaction of the clays and loose ash in these basins relative to the incompressible sandstone and igneous rocks underlying the gas rock elsewhere. Some of the irregularities may be the result of faulting of the gas rock, but the evidence for faulting is inconclusive. The gas rock is much thinner in the Jackson area than is the Selma group elsewhere in Mississippi and this is believed to be largely the result of nondeposition of the lower part of the Selma. The top of the Clayton is much higher at Jackson than at surrounding points. This difference in altitude may be partly the result of an upward movement of the core of sandstone and igneous rock in post-Clayton time, but also partly the result of compaction of the clays of pre-Selma Cretaceous formations on the sides of the original dome, which would cause the chalk and gas rock to settle on the sides of the dome but not on the rest of the dome, because there the gas rock was underlain by incompressible sandstone and igneous rock.

The smoothing out of the irregularities of the structure of the region as shown by a comparison of the maps of the top of the Clayton formation and of the top of the Cockfield formation is the result mainly of filling in of depressions by sediments of the Wilcox formation and the Claiborne group, which vary in thickness from place to place.

The magnitude of the anticline during Claiborne time is indicated by the much greater thickness of Wilcox sediments on the flanks of the anticline than on the crest. The formation averages about 1,200 feet in thickness on the crest of the anticline, but attains a thickness of 2,500 feet or more in wells a relatively few miles south of the anticline. This great difference in thickness is probably due in part to nondeposition at times when the Jackson anticline was an island in the shallow Wilcox sea and partly to erosion during and at the end of Wilcox time. The increase in the degree of doming of the Selma group and underlying formations indicated by the increase in the thickness of the Wilcox formation away from the Jackson anticline cannot be accounted for entirely by compaction of the shaly sediments beneath the Selma, but may be due in part to elevation of the center of the Jackson dome relative to the surrounding region.

The irregularities shown on the map of the top of the Clayton formation were not recognized in the map of the top of the Claiborne group—the structure of the rocks exposed at the surface. Part of this smoothing out of the dome is due to lack of structural data comparable in quantity to that available for the other structure maps, but it is also partly due to filling in of depressions on the surface of the Clayton by the early Tertiary sands and clays.

The writer has seen no evidence that the hypothetical fault between secs. 1 and 2 extends to the surface. Exposures on the Pearl River in sec. 11, and on the upland in sec. 25 indicate that the fault is not present in those areas. In fact there seems to be little, if any, faulting at the surface near Jackson.

The only way in which the relative importance of diastrophic uplift and of compaction of underlying sediments might be evaluated is to make a careful study of the total thickness of sand and shale or clay both on the crest of the anticline and on the sides. The writer does not have the needed information, but from a study of the drillers logs of wells drilled in the area, he estimates that the effect of compaction would be to lower the sides several hundred feet more than the central part of the dome.

GEOLOGIC HISTORY

PRE-TUSCALOOSA HISTORY

Nothing is known of the early geologic history of the Jackson area previous to the Jurassic(?) period. Indeed little is known of the history of the region until late Cretaceous time, but the presence of sediments of probable Jurassic age provides a starting point for a discussion of the geologic history.

In Jurassic time, at about the time the Malone sediments accumulated in the sea in western Texas, sand and red mud were deposited near shore or possibly above sea level in southern Arkansas, Louisiana, and southern Mississippi. The environment of these sediments is indicated by the presence of crossbedded sandstone, poorly assorted sandy silt and shale, and a few thin lenses of carbonaceous matter and coal. These sediments were later consolidated to form the Cotton Valley formation.

Away from the crest of the Jackson anticline there are said to be sediments of early Cretaceous Glen Rose age indicating that after the Jurassic the early Cretaceous sea also covered much of southern Mississippi. Only a few wells in the Jackson area have penetrated strata of this age, however, so little is known of the extent of this sea. It seems likely that Lower Cretaceous deposition in the Jackson area proceeded much as it did in northern Louisiana and southwestern Arkansas. As only older rocks of the Lower Cretaceous are found beneath the Tuscaloosa group in central Mississippi, the upper part of the Lower Cretaceous was either not deposited or was eroded away before Tuscaloosa time. Hence central Mississippi was probably land during most of this epoch and erosion was actively removing the recently deposited sediments of the Lower Cretaceous.

EARLY LATE CRETACEOUS EVENTS

Early in Late Cretaceous time the sea advanced northward to the southern edge of the Ouachita Mountains and to about the northern boundary of Mississippi and sediments of sand and clay were deposited to form the Tuscaloosa group. Intense vulcanism in parts of what is now Texas, Arkansas, Louisiana, and western Mississippi accompanied this deposition. Along certain zones where the crust was weaker than elsewhere, volcanoes opened permitting igneous rocks to reach the surface. One of these lines of volcanoes extends southeastward from Arkansas into Mississippi, apparently ending at

Jackson. Igneous rock forced its way upward through the sedimentary rocks, forming dikes, and penetrated laterally between bedding planes, forming sills, both of which have been encountered in the Cotton Valley(?) formation in wells near Jackson. Some igneous rock reached the surface and was blown into the air by the explosive force of the volcano to be deposited nearby as masses of volcanic ash and tuff.

The intrusion of the igneous rock at Jackson apparently baked some of the sands and clays of the Cotton Valley(?) formation into sandstones and shales, and in places hot solutions penetrated the sands and caused the grains to grow into small euhedral quartz crystals. These intrusions raised the Cotton Valley(?) sediments into a high hill in which the rocks had the general attitude of a dome, but in which the individual beds were probably broken by numerous faults and possibly crumpled into local folds.

At the time all this was happening in the Jackson area Tuscaloosa sediments were being deposited in the sea toward the south, east, and northeast of Jackson. Some ash accumulated in the waters of Tuscaloosa time at nearby points. The high hill at the site of Jackson projected as an island from the sea and erosion carved this island into an irregular topography. Some depressions on the surface of the island, possibly originally volcanic vents, were partly filled by volcanic ash and tuff, as shown by the Harris well, and then the ash was covered by carbonaceous clay deposited either in lakes or arms of the sea protected from direct wave action and strong currents.

Deposition of the Tuscaloosa group was succeeded by that of the Eutaw formation. It is not known whether any of the Eutaw was deposited over the top of the Jackson island; any such material was eroded before deposition of the overlying gas rock. Near Jackson the sediments of Eutaw age consisted primarily of sandy clay with subordinate amounts of sand and in places very chalky sand.

LATE CRETACEOUS EVENTS

Throughout most of early Selma time the Jackson island remained above sea level, but late in Selma time possibly at the beginning of Prairie Bluff time, sea level began to rise relative to the land and the Jackson island gradually sank below the surface of the sea. Subsidence continued until the old land surface of the island was at least 300 feet below sea level. With disappearance of the Jackson island the nearby source of sediments for the Upper Cretaceous sea was lost and only calcium carbonate was deposited possibly as fringing reefs to form the exceedingly pure chalk of the gas rock. Numerous large orbitoid foraminifers, bryozoa, and corals lived in the sea, suggesting that the water was relatively shallow and in general quite warm—tropical rather than temperate. Throughout Selma and Prairie Bluff time clayey and sandy chalk was deposited at places not far from the Jackson area suggesting that conditions permitting very clear water were relatively local and that at places toward the north and east the water was not as clear.

PRE-TERTIARY EROSION

At the end of the Cretaceous period the newly formed sea bottom was raised above sea level and eroded by streams. How long this period of erosion lasted is not known, but it may have been long even in terms of geologic time, which is measured in terms of thousands of years, for the next sea that covered the area in the Paleocene contained an assemblage of animals entirely different from that of the Cretaceous sea, many of the animals being evolutionary descendants of the Cretaceous species. During this erosion interval the gas rock at Jackson was gently folded partly by settling in those places where it overlay basins filled with ash and clay as the water enclosed in the pores of the ash and clay was pressed out by the weight of the overlying rock. Basins were formed in the top of the chalk, in appearance much like sink-hole depressions in limestone regions. At the same time the land along the sides of the buried hill, formerly an island in the Tuscaloosa sea, was sinking relative to the top by compaction of the clays of the Eutaw and Tuscaloosa into shales. In addition there may have been a general upwarping of the igneous core of the ancient island. The net result of all these movements was that the land above the ancient Jackson island stood at a higher altitude than the surrounding country. Streams probably cut deeper valleys into the top of the gas rock, giving rise to some of the depressions found by wells drilled at Jackson.

DEPOSITION OF TERTIARY SEDIMENTS

At the beginning of the Paleocene the land again sank below sea level and the sea transgressed across the recent land surface. The hill at Jackson probably projected from the sea as an island until late in Paleocene (Midway) time, for the Midway group is much thicker on the sides than on the crest of the anticline, and the foraminifers found in the basal part of the Midway at Jackson are known only in the upper part of the Midway elsewhere. The earliest sediments of the Midway consist of dense slightly clayey limestone suggesting that the limestone or chalk near the surface was reworked or taken into solution by the transgressing Midway sea and deposited as a limy ooze that contained clay from an extraneous source and a few Midway fossils. As this limestone layer is very thin, the readily available calcium carbonate was apparently soon all precipitated, and only dark-gray to black clay continued to be deposited. This clay, the Porters Creek clay, attained a thickness of as much as 800 feet near Jackson, but only the upper hundred feet or less is present on the crest of the Jackson anticline.

Deposition of the Midway group was succeeded by deposition of sandy brown clay of late Paleocene or early Eocene age, generally considered in the Jackson area the lower part of the Wilcox formation. The writer knows little about the sediments of the Wilcox and overlying Claiborne group but from the few samples studied believes that the Wilcox sediments were deposited in swamps, deltas, and possibly shallow marine water. During this deposition the sea bottom was sinking, probably faster away from Jackson than at Jackson, for the Wilcox is only half as thick at Jackson as elsewhere. Wilcox time closed with a withdrawal of the sea that may have permitted some erosion of the Wilcox sediments, but this is not shown by the well samples.

The Claiborne epoch opened with a transgression of the sea across the southern and western halves of Mississippi. Glauconitic chalk, sand, clay, and limestone were deposited as the sea bottom continued to sink relative to the land. When the rate of deposition of sediments eventually exceeded the rate of sinking, deltas were built southward across the deeper marine deposits to form the Sparta sand. An increase in the rate of sinking permitted a new transgression of the sea during which marl and limestone of the Cook Mountain formation were deposited. Again the rate of deposition exceeded the rate of sinking and deltas were built out into the sea forming the Cockfield formation. For short periods the delta surface was above sea level and plants grew and died to form thin deposits of lignite.

The Jackson epoch began with a transgression of the sea marked by the disconformity between the Cockfield formation and the Moodys Branch formation. An acceleration of the sinking of the land relative to sea level permitted the Jackson sea to advance over the Cockfield delta, and sand and clay-balls, in large part derived from the Cockfield formation, were deposited with glauconite and abundant shells, foraminifers, and solitary corals to form the lower part of the Moodys Branch formation. After a relatively short time the amount of sand available was not as great as the amount of clay and the deposits became more clayey, eventually becoming almost pure calcareous clay. The sea bottom continued to sink permitting an accumulation of nearly 450 feet of marine material, but then deltas again began to build out over the clay deposit (Yazoo clay) to form the basal part of the Forest Hill sand. Farther east in Mississippi deposition was interrupted at the end of Yazoo time, as is shown by the hiatus between the Yazoo clay and the Red Bluff clay. In the Jackson area, however, no evidence has been seen of any break between the Yazoo and the Forest Hill sand, which is the western equivalent of the Red Bluff clay. A small discontinuous carbonaceous clay bed in the lower part of the Forest Hill sand may represent a time of emergence equivalent in the west to the hiatus between the Yazoo and Red Bluff, but this carbonaceous zone has not yet been traced eastward.

During Forest Hill time deltaic deposition continued in western Mississippi. The deltas built themselves above sea level and coastal swamps formed as shown by two beds of lignite near the top of the Forest Hill sand. The general aspect of the Jackson area at this time must have been much like that of southern Louisiana today. Between the various delta distributaries local subsidence of the land gave rise to lagoons in which clay was deposited and in which a few shell fish lived.

A rather sudden subsidence brought an end to Forest Hill deposition and allowed the sea again to sweep across the area and deposit the Mint Spring marl member of the Marianna limestone. As in Moodys Branch time conditions were favorable for abundant molluscan life and also for the preservation of the shells in calcareous glauconitic sand. Coarser material was deposited at first, and the prevalence of strong wave and current action rolled shells about, rounding them and breaking some. As the sea bottom sank, the water became quieter and finer sediments and less water-worn shells were deposited. After a fairly short period, the rate of deposition became very slow; only a little phosphatic sand was deposited in the Jackson area while the Marianna limestone ("chimney rock") was being deposited in eastern Mississippi, Alabama, and Florida. Active deposition again began at the start of Byram time.

Early Byram time is the period of most widespread limestone-forming conditions in the Tertiary of the eastern Gulf region. In western Mississippi varying mixtures of clay and calcium carbonate were deposited to form the alternating hard and soft layers of marly limestone of the Glendon member. Glendon deposition was succeeded by an influx of more sand which permitted many more mollusks and corals to live and the middle marl member of the Byram formation was deposited. Toward the end of this period of deposition much more clay and less sand began to fall from the sea water. The actual cause is not known, but it may have been a diversion of muddy water from some ancestral Mississippi River. The mud contained considerable carbonaceous matter and its deposition gave rise to the black Bucatunna clay member. Locally small colonies of mollusks of the Byram species continued to live in more sandy spots, and thus the small lenticular bodies of sandy, fossiliferous clay common in the upper part of the Bucatunna were deposited.

In the Jackson area the carbonaceous clays of the Bucatunna clay member were buried by deposits of thin-bedded sand and clay, although in eastern Mississippi Bucatunna sedimentation was followed by deposition of the sandy limestone of the Chickasawhay limestone. Elsewhere in the eastern Gulf region the Chickasawhay sea transgressed to the north over the Oligocene and in Georgia over upper Eocene deposits.

If the writer's interpretation of the top of the thin sand and clay unit is correct, forest vegetation covered the ground for a short time to form a characteristic forest soil in the topmost sandy clay.

Early in the Miocene epoch sand with subordinate amounts of clay was deposited over much of the Jackson area. This material of the Catahoula sandstone was probably deposited in marine waters near shore, but in contrast with the underlying transgressive marine deposits such as the Moodys Branch formation and the Mint Spring marl member of the Marianna limestone no record of early Miocene marine life has been found in west-central Mississippi. Some of the sand was deposited in lagoons that may have been completely landlocked by barrier beaches. The sun was probably hot and the climate somewhat arid, for sea water brought into the lagoons by the tides was concentrated by evaporation and salt was deposited with sand to form the salty sandstones.

At the end of Catahoula time the Jackson area was raised above sea level and no younger formations were deposited in the open sea. Erosion after the uplift reduced the region to a very flat surface, probably not unlike the surface of the Yazoo clay as it is today. The region probably had low cuestas caused by the more resistant sandy formations resting on easily eroded clay formations, such as the cuesta formed at the contact of the Yazoo clay and the Forest Hill sand.

LATE TERTIARY AND QUATERNARY EVENTS

Late in Pliocene or early in Pleistocene time the rivers and streams entering the region from the north and northeast brought in large amounts of sand and coarse gravel. This probably indicates an uplift of the parts of Mississippi, Alabama, and Tennessee that contain the chert-bearing limestones of Mississippian age, for much of the gravel is derived from these formations. An alternative possibility of a great increase in the rainfall in that region would cause floods powerful enough to carry this gravel 200 miles across Mississippi on a relatively gentle gradient and deposit it in flood plains in the southern part of the State. More likely there was both upwarping and an increase in rainfall. Whatever the cause the thick cherty soils of the limestone region were swept away and deposited as the great gravel deposits of the Citronelle formation of southern Mississippi.

After deposition of the Citronelle formation an uplift of the Jackson area permitted erosion of enough of the gravel deposit to expose the underlying Eocene, Oliogocene, and Miocene deposits. A small downwarping of the area allowed the irregularities of the surface to be filled by river flood-plain deposits that give rise to the high-level gravel deposits. Later raising of the land or lowering of base level of the streams permitted the streams to cut lower flood plains, which are now preserved as the lower river terraces of the region.

The melting of the ice sheets in the northern United States filled the Mississippi River with water loaded with finely ground rock flour, which was spread over its flood plain at high water only to be blown away at times when the river returned to its channel. This fine material accumulated as a blanket of loess over the surface of all the older formations in the region; thickest near the Mississippi River and progressively thinner toward the east.

Since deposition of the loess the streams of the Jackson area have widened their flood plains somewhat, and have deposited thin alluvial deposits composed of reworked loess, loam, sand, and clay. The Big Black River drainage has been rapidly eroding its way back into the drainage basin of the Pearl River until remnants of the floor of the gentle southeastward sloping, loess-covered Pearl River drainage basin are now preserved well within the Big Black drainage basin in the northeastern part of the Jackson quadrangle in T. 7 N., R. 1 E. The rapid extension of the Big Black drainage basin is continuing today, and may be expected to divert more of the Pearl drainage in the future.

ECONOMIC GEOLOGY

NATURAL GAS AND OIL

OCCURRENCE

Natural gas and oil have been obtained in the Jackson area from limestone directly underlying the uppermost bed of the Clayton formation of the Midway group. Whether the accumulation is entirely within the underlying gas rock of Cretaceous age, or whether some of the gas may also be in the basal part of the Clayton has not been determined. It seems certain, however, that most of the gas was stored in the gas rock. The rock originally contained gas to a depth of about 2,200 feet below sea level, although a few wells produced gas and salt water from slightly greater depths. The writer believes that before the first well was drilled in the gas field all the pore space of the gas rock above 2,200 feet below sea level was filled with gas; that is, that the gas-bearing part of the rock was not confined to any single bed, but that the entire formation may be considered a single bed containing gas and salt water. The presence of the gas then was dependent largely on the configuration of the surface of the formation—the higher parts contained gas and the basins, synclines, and ancient erosion channels that reached depth greater than 2,200 feet did not contain gas.

The gas in this field contained no condensate. In the southern part, particularly in secs. 14 and 15, T. 5 N., R. 1 E., a few wells produced some oil of 13.6° API gravity. Henry N. Toler (oral communication) when he was State Oil and Gas Supervisor, estimated that the total oil production was of the order of 25,000 barrels.

Some of the wells, particularly in the northern part of the gas field, were completed with unsatisfactory casing which permitted gas to leak into the porous sands of the Wilcox formation. The first well drilled by the State of Mississippi (Fee No. 1) in sec. 25, T. 6 N., R. 1 E., was lost in 1936, when this stray gas, which had accumulated at the top of the Wilcox blew out when the well reached a depth of 1,095 feet. The State then drilled Fee No. 3 nearby to a depth of 1,107 feet and obtained from the top of the Wilcox 102,446,000 cubic feet of this stray gas. Although the gas was produced from the top of the Wilcox formation, its source in all probability was in the gas rock as in the other gas wells in the Jackson field.

The great irregularities in the top of the producing bed caused considerable difficulty in the development of the field, for it was impracticable to predict the top of the cap rock even within the proved limits of the field.

HISTORY OF DEVELOPMENT

In 1917 shortly after Hopkins (1916, pp. 113–114) called attention to the Jackson anticline as a favorable structure for the accumulation of oil and gas, Benedum and Trees and the Atlas Oil Co. each drilled test holes, but both wells were drilled north of the area now known to be productive. In 1927 Mrs. Ella Rawls Reeder began drilling a well on the State Insane Asylum property north of Jackson. After many difficulties her well was finally drilled into the gas rock, but for some unknown reason gas was not obtained, although the site of her well was later surrounded by producing gas wells.

In September and October 1929, a local company, the Home Oil Producing Co., drilled the Rainey No. 1 well in the northern part of sec. 13, T. 5 N., R. 1 E., Rankin County. This well reached the top of the Clayton formation (cap rock) at a depth of 2,241 feet below sea level, a little too deep to produce gas, but the showings were so favorable, that the driller, Cleve Love, drilled the Mayes No. 1 well for another local company, the Jackson Oil and Gas Co., in sec. 2, T. 5 N., R. 1 E. This well was brought in as a gas well in February 1930 with the cap rock at a depth of 2,187 feet below sea level, and produced 1,700,335,000 cubic feet of gas until it was drowned by salt water in May 1939.

The second well in the field, the Love Petroleum Co.'s Mendoza Club No. 1, sec. 11, T. 5 N., R. 1 E., was completed as a gas well in April 1930, with the Clayton formation (cap rock) at a depth of 2,176 feet below sea level. Although other wells had a greater initial capacity, this well produced more gas than any other well in the field. When it was finally flooded by salt water in August 1938, it had produced 4,075,379,000 cubic feet of gas.

Drilling proceeded rapidly through 1932, and a few gas wells were completed every year through 1940, as shown by the following table:

Wells completed, by years

	1917	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	Total
Gas wells	----	----	30	35	35	15	8	5	2	3	6	1	1	141
Gas well lost by blow out	----	----	----	----	----	----	----	----	1	----	----	----	----	1
Small gas wells never on pipe line	----	----	2	2	1	4	----	1	----	----	----	----	1	11
Dry holes in limits of field	----	1	12	11	4	2	----	4	4	1	1	3	1	44
Dry holes drilled outside limits of field	2	1	3	6	2	1	6	----	----	----	----	1	3	25
Total wells drilled	2	2	47	54	42	22	14	10	7	4	7	5	6	222

INITIAL PRODUCTION

The initial open flow capacities of gas wells as measured with the Pitot tube ranged from less than 1 million to more than 50 million, with most of the wells gaging between 30 and 40 million. The initial shut-in pressure of the field was about 1,000 pounds per square inch, although a few wells are reported to have gaged as high as 1,080 pounds. So many different instruments were used in early measurements that it is difficult to determine the true original pressure of the field, but the figure of 1,000 pounds is probably nearly correct. Pressure declined slowly as the gas was withdrawn, but because salt water advanced from the sides to replace the gas withdrawn, the pressure rarely dropped below 800 pounds before the wells were drowned by the advancing water.

PRODUCTION OF GAS

Most of the gas produced in the field was sold to the United Gas Public Service Co., the Mississippi Power and Light Co. (for sale to customers in Jackson and Clinton), and the East Side Oil and Gas Co.

(for sale to customers in East Jackson). The Willmut Gas and Oil Co. owned several wells in the field to supply their pipe line to Hattiesburg, Miss., and the city of Canton owned 2 wells on property of Belhaven College, which supplied a municipal pipe line to Canton.

Sale of gas began in 1930 and the volume sold increased each year, except for a slight reduction in 1934, until the field became nearly exhausted in 1939. The following table compiled from reports of the office of the State Oil and Gas Supervisor shows the production of the field for each year from 1930 through 1950:

Production of gas in the Jackson gas field

[In thousands of cubic feet]

Year	Gas metered	Gas wasted and used in drilling (estimated)	Total production	Number of producing wells
1930	351,643	235,000	586,643	5
1931	5,940,370	224,000	6,164,370	47
1932	9,072,935	601,718	9,674,653	87
1933	9,375,972	30,000	9,405,972	102
1934	8,976,229	25,000	9,001,229	110
1935	10,265,923	25,000	10,290,023	114
1936	12,938,571	30,000	12,968,571	109
1937	14,046,168	375,000	14,421,168	98
1938	14,273,010	25,000	14,298,010	90
1939	15,232,652	25,000	15,257,652	54
1940	6,448,737	25,000	6,473,737	32
1941			3,878,472	23
1942			2,084,061	23
1943			1,349,936	19
1944			852,000	18
1945			621,670	15
1946			473,603	15
1947			352,904	15
1948			323,456	14
1949			289,051	13
1950			231,733	12
Total			118,999,904	

The total production of the field will probably be approximately 120,000,000,000 cubic feet, which is very close to the estimate of Munroe (1935, p. 896) of 128 billion cubic feet, and of Toler (oral communication, 1937) of 110 billion cubic feet.

GROUND WATER

In the more porous formations within the Jackson area, including the Cockfield formation, the Forest Hill sand, the Catahoula sandstone, and the various gravel deposits and alluvium, shallow ground water may be obtained from springs and shallow wells. In the region underlain by the impervious Yazoo clay, however, deep wells must be drilled to one of the underlying porous formations, usually

268680—54——9

the Cockfield, although a few small farm wells obtain hard water from the lower part of the Moodys Branch formation. The structure contours on the geologic maps (pls. 1–4) show the altitude of the top of the Cockfield, and the depth to the Cockfield may be obtained by subtracting this figure from the altitude of the surface at the point desired.

Large companies, hotels, and others who need larger supplies of water than the Cockfield formation will furnish, obtain them from deeper sands of the Sparta and the Wilcox formations. Large flows have been obtained from these deeper formations in places low enough for artesian flow, and large amounts can be pumped from higher altitudes.

The Ground-Water Branch of the Geological Survey is now making a study of the underground-water resources of Mississippi and will obtain detailed information on the deeper sands.

SAND AND GRAVEL

The principal use of the sand and gravel resources of the area is for road metal. Much of the gravel used in the Jackson area is brought in from the large pits near Brookhaven and Crystal Springs farther south in the State, where the gravel is mined from the Citronelle formation. Local needs are filled, however, from the high-level gravel deposit and stream terrace deposits shown on the geologic maps (pls. 1–4). In general the gravel of the Citronelle formation is coarser and more suitable for road metal than the other deposits.

CLAY

No large deposits of pottery clay are known in the Jackson area, but much material suitable for the manufacture of bricks is available. Two brick plants near Jackson use as the raw material the highly weathered and leached loess, known as the brown loam. The Johnson-Cone Brick Co. north of Jackson in sec. 21, T. 6 N., R. 1 E., Hinds County, strips off 14 feet of brown loam from the surface of the ground down to the top of the Yazoo clay, and finds the material entirely satisfactory for brick manufacture. The unleached loess is doubtless too calcareous for use in brick making, but the brown loam seems to be satisfactory. The Jackson Brick Co. in sec. 16, T. 5 N., R 1 E., satisfactorily used alluvium of Lynch Creek, which is composed almost entirely of reworked loess and reworked, weathered Yazoo clay.

Small quantities of high-grade bentonite suitable for treatment as a bleaching clay have been found in the Byram formation near Byram, but the beds are only a few inches thick and the quantity is thus not sufficient for commercial exploitation. Low grade bleaching clay, or fuller's earth, was obtained from the Bucatunna clay member northeast of Brandon and at a few other places, and near the top of the Yazoo clay half a mile north of Goshen Springs in sec. 5, T. 7 N., R. 4 E., but neither deposit is of any commercial value at present.

BUILDING STONE AND RIPRAP

The indurated layers of the Catahoula sandstone have been used as building stone in the old State Capitol building and as riprap for the protection of levees, but none of this has been quarried within the Jackson area, as mapped. The quarry (fig. 11) that produced much of the stone for use in buildings in Jackson is near the Raymond road in the SW¼NW¼ sec. 23, T. 5 N., R. 2 W., Hinds County. The stone is generally used as a veneer on frame houses. The Gant quarry near Terry has also produced some stone for this purpose, but most of the output was used as riprap on levees and for the airport at New Orleans, La.

Considerable limestone was taken from the Robinson quarry in sec. 19, T. 5 N., R. 4 E., Rankin County, and used in the foundation of the new State Capitol at Jackson, but according to Crider (1907, p. 64) "work was discontinued because of the great amount of useless marl which had to be removed to get the rock." In general the Glendon limestone member of the Byram formation, the rock exposed at the quarry, weathers too rapidly to be entirely suitable as a building stone. Use of the Glendon for tombstones in country cemeteries has been noted, but after a few years the carving on the stones has become dim because of the rapid weathering of the rock.

CEMENT MATERIALS

It has long been suggested that the limestone of the Vicksburg group be used for the manufacture of portland cement, but the economics of the cement industry are such that a ready market must be available before a company is justified in building an expensive plant, even at places where the raw materials are superior. Up to the present Mississippi has been adequately supplied with cement from plants in Alabama, Louisiana, and Texas, and until the price of transporting cement from these existing plants becomes much higher there is little possibility that a plant can be built to operate profitably in the Jackson area. If such a plant is needed at some future time, the Vicksburg would prove to be an excellent source of raw material. Crider (1907, pp. 59–65) has published analyses of the Glendon limestone member of the Byram formation exposed near Byram, Plain, and Robinson's quarry, which show limestones and marl well suited for the manufacture of cement. He says (p. 60):

A large number of analyses of the marls from different localities show that they contain no large amounts of injurious properties, and can be used for cement as they come from the quarry. The marls and the clays supply the silica and alumina for Portland cement and are therefore of equal value to the limestone. In fact, by taking a general average of the analyses of the limestones and the interbedded marls we obtain the desired mixture for a Portland cement, without the addition of other materials.

LITERATURE CITED

Bay, H. X., 1935, A preliminary investigation of the bleaching clays of Mississippi: Mississippi Geol. Survey Bull. 29.

Berry, E. W., 1916a, The flora of the Citronelle formation: U. S. Geol. Survey Prof. Paper 98-L, pp. 193–208.

——— 1916b, The flora of the Catahoula sandstone: U. S. Geol. Survey Prof. Paper 98-M, pp. 227–251.

——— 1924, The middle and upper Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 92.

Blanpied, B. W., Oldham, A. E., and Alexander, C. I., 1934, Stratigraphy and paleontological notes on the Eocene (Jackson group), Oligocene and lower Miocene of Clarke and Wayne Counties, Miss., Eleventh Ann. Field Trip of the Shreveport Geol. Soc., 52 pp.

Canu, Ferdinand, and Bassler, R. S., 1920, North American early Tertiary Bryozoa: U. S. Natl. Mus. Bull. 106, 879 pp.

Casey, T. L., 1901, On the probable age of the Alabama white limestone: Acad. Nat. Sci. Philadelphia Proc., v. 53, pp. 513–518.

Conrad, T. A., 1848, Observations on the Eocene formation, and description of 105 new fossils of that period, from the vicinity of Vicksburg, Miss.: Acad. Nat. Sci. Philadelphia Proc. [1847], 1st ser., v. 3, pp. 280–299.

——— 1855, Observations on the Eocene deposit of Jackson, Miss., with descriptions of thirty-four new species of shells and corals: Acad. Nat. Sci. Philadelphia Proc., 1st ser., v. 7, pp. 257–263.

Cooke, C. W., 1918, Correlation of the deposits of Jackson and Vicksburg ages in Mississippi and Alabama: Washington Acad. Sci. Jour., v. 8, pp. 186–198.

——— 1922, The Byram calcareous marl of Mississippi: U. S. Geol. Survey Prof. Paper 129-E, pp. 79–85.

——— 1923, The correlation of the Vicksburg group: U. S. Geol. Survey Prof. Paper 133, pp. 1–9.

——— 1926, The Cenozoic formations, *in* Geology of Alabama: Alabama Geol. Survey, Special Rept. 14, pp. 251–297.

——— 1935, Notes on the Vicksburg group: Am. Assoc. Petroleum Geologists Bull., v. 19, no. 8, pp. 1162–1172.

——— 1939, Equivalence of the Gosport sand to the Moodys marl: Jour. Paleontology, v. 13, no. 3, pp. 337–340.

Crider, A. F., 1906, Geology and mineral resources of Mississippi: U. S. Geol. Survey Bull. 283.

——— 1907, Cement and portland cement materials of Mississippi: Mississippi Geol. Survey Bull. 1, 73 pp.

Croneis, C., and Billings, M. P., 1930, Igneous rocks in central Arkansas: Arkansas Geol. Survey Bull. 3, pp. 149–162.

Cushman, J. A., 1922, The Foraminifera of the Byram calcareous marl at Byram, Miss.: U. S. Geol. Survey Prof. Paper 129-E, pp. 87–122.

Gardner, J. A., 1927, The correlation of the marine Yegua of the type sections: Jour. Paleontology, v. 1, no. 3, pp. 245–251.

Goldman, M. I., 1915, Petrographic evidence on the origin of the Catahoula sandstone of Texas: Am. Jour. Sci., 4th ser., v. 39, pp. 261–287.

Grim, R. E., 1928, Recent oil and gas prospecting in Mississippi with a brief study of subsurface geology: Mississippi Geol. Survey Bull. 21, 98 pp.

——— 1936, The Eocene sediments of Mississippi: Mississippi Geol. Survey Bull. 30, 240 pp.

Harper, Lewis, 1857, Preliminary report on the geology and agriculture of the State of Mississippi: 350 pp., Jackson, Miss.

Harris, G. D., 1894, On the geological position of the Eocene deposits of Maryland and Virginia: Am. Jour. Sci., 3d ser. v. 47, pp. 301–304.

Hilgard, E. W., 1860, Report on the geology and agriculture of the State of Mississippi, 391 pp., Jackson, Miss.

Hopkins, O. B., 1916, Structure of the Vicksburg-Jackson area, Mississippi, with special reference to oil and gas: U. S. Geol. Survey Bull. 641–D, pp. 93–120.

Hughes, U. B., 1938, Detailed study of Bucatunna-Vicksburg contact in Smith County, Miss. (abstract): Am. Assoc. Petroleum Geologists, Program 23d Ann. Meeting, New Orleans, La., p. 11.

Langdon, D. W., 1886, Observations on the Tertiary of Mississippi and Alabama, with descriptions of new species: Am. Jour. Sci., 3d ser., v. 31, pp. 202–209.

Logan, W. N., 1907, Clays of Mississippi: Mississippi Geol. Survey Bull. 2, 255 pp.

Lowe, E. N., 1915, Mississippi: its geology, geography, soils, and mineral resources: Mississippi Geol. Survey Bull. 12, 335 pp.

——— 1919a, Mississippi: its geology, geography, soil and mineral resources: Mississippi Geol. Survey Bull. 14, 346 pp.

——— 1919b, Oil and gas prospecting in Mississippi: Mississippi Geol. Survey Bull. 15, 80 pp.

——— 1923, Petroleum prospecting in Mississippi: Ninth biennial report, 1921–23, of the Director of the State Geological Survey to the Mississippi Legislature, pp. 3–14.

——— 1925, Geology and mineral resources of Mississippi: Mississippi Geol. Survey Bull. 20, 151 pp.

Lyell, Charles, 1847, On the relative age and position of the so-called nummulite limestone of Alabama: Am. Jour. Sci., 2d ser., v. 4, pp. 186–191.

——— 1849, A second visit to the United States of America; v. 2, 287 pp., New York.

McCutcheon, T. E., 1940, Yazoo County mineral resources; Tests: Mississippi Geol. Survey Bull. 39, pp. 73–132.

Matson, G. C., 1916a, The Pliocene Citronelle formation of the Gulf Coastal Plain: U. S. Geol. Survey Prof. Paper 98–L, pp. 167–192.

——— 1916b, The Catahoula sandstone: U. S. Geol. Survey Prof. Paper 98–M, pp. 209–226.

Mellen, F. F., 1940, Yazoo County mineral resources; Geology: Mississippi Geol. Survey Bull. 39, pp. 9–72.

Meyer, Otto, 1885, The genealogy and the age of the species in the southern old Tertiary: Am. Jour. Sci., 3d ser., v. 29, pp. 457–468.

Miser, H. D., and Purdue, A. H., 1929, Geology of the De Queen and Caddo Gap quadrangles, Ark.: U. S. Geol. Survey Bull. 808, 195 pp.

Monroe, W. H., 1932a, Earth cracks in Mississippi: Am. Assoc. Petroleum Geologists Bull., v. 16, no. 2, pp. 214–215.

——— 1932b, The Jackson gas field, Hinds and Rankin Counties, Miss.: U. S. Geol. Survey Bull. 831–A, pp. 1–17.

——— 1933, Pre-Tertiary rocks from deep wells at Jackson, Miss.: Am. Assoc. Petroleum Geologists Bull., v. 17, pp. 38–51.

Monroe, W. H., and Toler, H. N., 1937, The Jackson gas field and the State deep test well: Mississippi Geol. Survey, Bull. 36, 52 pp.

Moody, C. L., 1949, Mesozoic igneous rocks of northern Gulf Coastal Plain: Am. Assoc. Petroleum Geologists Bull., v. 33, no. 8, pp. 1410–1428.

Mornhinveg, A. R., and Garrett, J. B., Jr., 1935, Study of Vicksburg group at Vicksburg, Miss.: Am. Assoc. Petroleum Geologists Bull., v. 19, no. 11, pp. 1645–1667.

Morse, W. C., 1935, Geologic conditions governing sites of bridges and other structures: Mississippi Geol. Survey Bull. 27, 19 pp.

Munroe, D. J., 1935, Jackson gas field, Hinds and Rankin Counties, Miss., *in* Ley, H. A. and others, Geology of natural gas: pp. 881–896, Tulsa, Okla., Am. Assoc. Petroleum Geologists.

Purdue, A. H., and Miser, H. D., 1923, Description of the Hot Springs quadrangle, Arkansas: U. S. Geol. Survey Geol. Atlas folio 215.

Richards, H. G., 1938, Some Pleistocene freshwater mollusks from Louisiana and Mississippi, *in* Contributions to the Pleistocene history of the Florida Parishes of Louisiana: Louisiana Geol. Survey Bull. 12, pp. 27–46.

Ross, C. S., Miser, H. D., and Stephenson, L. W., 1929, Water-laid volcanic rocks of early Upper Cretaceous age in southwestern Arkansas, southeastern Oklahoma, and northeastern Texas: U. S. Geol. Survey Prof. Paper 154–F, pp. 175–202.

Ross, C. S., and Stephenson, L. W., 1939, Calcareous shells replaced by beidellite: Am. Mineralogist, v. 24, no. 6, pp. 393–397.

Shaw, E. W., 1918, The Pliocene history of central and northern Mississippi: U. S. Geol. Survey Prof. Paper 108–H, pp. 125–163.

United States Bureau of Chemistry and Soils, 1926, Soil survey of Rankin County, Miss.: ser. 1926, no. 27, U. S. Dept. Agriculture.

Vaughan, T. W., 1895, Stratigraphy of northwestern Louisiana: Am. Geologist, v. 15, pp. 205–229.

Vaughan, T. W., and Cole, W. S., 1932, Cretaceous orbitoidal Foraminifera from the Gulf States and Central America: Nat. Acad. Sci. Proc., v. 18, no. 10, pp. 611–616.

Veatch, A. C., 1905, The underground waters of northern Louisiana and southern Arkansas: Louisiana Geol. Survey Bull. 1, pt. 2, pp. 81–164.

——— 1906, Geology and underground water resources of northern Louisiana and southern Arkansas: U. S. Geol. Survey Prof. Paper 46.

Wailes, B. L. C., 1854, Report on the agriculture and geology of Mississippi, 371 pp., Jackson, Miss.

Wedel, Arthur, and others, 1941, Subsurface sections of central Mississippi, chiefly Cretaceous, Mississippi Geol. Soc., Study Group Comm., 6 pp.

Williams, J. F., 1891, The igneous rocks of Arkansas: Arkansas Geol. Survey Ann. Rept., v. 2, pp. 1–391, 429–457.

INDEX

O